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SCIENCE & TECHNOLOGY
JAPAN
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[Excerpts] Chapter 1. Establishing an Environment for Creative Research

Part 1. Need To Improve Research Environment To Promote Creative R&D

With the advancement of Japan's S&T standards and international role, we must strengthen creative R&D, especially in basic research, from our own necessity, as well as to construct better international relations. As for Japan, the completion of a better research environment is a requisite.

In this section, the trends of S&T policies and basic research being conducted worldwide will first be explained, followed by an analysis of the conditions and standards of Japan's basic research. Finally, the basic problems concerning the completion of a better research environment will be discussed.

1. Trend of International Scientific Research and Japan's S&T Policy Development Seen From an International Viewpoint

Summary of Revised U.S.-Japan S&T Agreement

An outline of the Revised U.S.-Japan S&T Agreement follows. The validity of this agreement is 5 years, starting from the date it was signed (20 June 1988).

Preface

In recognition of the necessity of liability contributions in S&T by both nations for the world's prosperity and welfare, a policy framework to promote overall S&T relations between both governments was determined and announced as strengthened for peaceful purposes.

Principles concerning S&T relations between both nations

The following five principles were determined to apply to the overall S&T relations between the governments of the United States and Japan.

(I) Liability apportionments in accordance with the capacity and resources of both nations in the respective S&T fields and mutual and fair contributions and profits

(II) Proper opportunities for researchers to use major government assisted projects and facilities in S&T, R&D fields and also to use and exchange information involving these fields

(III) Sufficient and effective protection and just apportionment of intellectual properties yielded during cooperation, along with sufficient and effective protection of intellectual properties introduced during cooperation

(IV) Diffusion of information in conformity with the applicable domestic ordinance (including that related to security) to the widest extent

(V) Allotment of expenses related to cooperation after taking into consideration the respective risk-bearing, profits and share of management.

Major fields of cooperation

Seven fields, namely, biotechnology including life science, information science and technology, manufacturing engineering, automation and process control, earth science and earth environment, joint data base development and advanced materials including supercomputers, were determined as the cooperative activities based on this agreement.

Nongovernmental service

Private researchers and organizations may participate in this agreement, if deemed appropriate, and private research projects may also be included in the cooperative activities based on this agreement, if they are major programs subsidized by the government.

Balanced access to R&D activities

Since the R&D activities in Japan are not necessarily open, as is the case in the United States, there is a quantitative imbalance in the exchange of researchers, the mutual application of information, etc., between Japan and the United States (the number of Japanese researchers working in the United States far surpasses the number of American researchers working in Japan, and there is also a greater amount of information coming into Japan from the United States). There is also a view that Japan is profiting one-sidedly by industrializing the knowledge yielded in the United States. Under these circumstances, the participation of researchers in the other nation's R&D activities and the access to their information have been discussed. It was confirmed that both nations should secure well-balanced access to each other's R&D activities and information.

Consequently, both nations agreed to continue making R&D systems available to the world, revise language training programs for the other nation's researchers, provide opportunities for their reception, supply government-

sponsored fellowships and improve the supply of information to the other nation.

Providing occasions to discuss S&T of both nations

Dialogues between both nations shall be promoted through a high-level joint committee to discuss S&T priorities of the American and Japanese governments. A working-level joint committee to prepare for the former committee and a high-level joint advisory organ composed of experts from academic and industrial circles shall also be set up.

Intellectual properties

From the standpoint of protecting intellectual properties, the United States has proposed that general provisions concerning the treatment of intellectual properties, which was previously handled on a case-by-case basis, be included in the agreement. After deliberation, it was confirmed that sufficient and effective protection and just apportionment of intellectual properties shall be a principle included in the agreement. It was also agreed that intellectual properties generated during the activities shall be handled on a case-by-case basis, as before, by individual settlements, etc., of the parties concerned. If there are no new settlements, provisions for the protection and apportionment of intellectual properties generated only during the exchange of information and researchers will be provided and followed, as a rule. Especially when inventions, etc., result from cooperation through the exchange of researchers, except when the reception side has made a major and essential contribution (in this case, the reception side may acquire every right in every area), both sides may acquire the respective rights in each country or a third nation. With joint projects, these properties shall be handled case by case, based on fair principles.

Handling information from the standpoint of security

Since the cooperative activities of this agreement are being conducted for peaceful purposes, both governments must support the diffusion of the information and materials originated during the process, to the greatest extent possible. Information and materials which have been confidential due to reasons involving national defense cannot be employed, as stated in the principle that an open research environment must be maintained. It was also confirmed that information and materials which have been supplied or produced during these activities and are subject to export control can be transferred after taking the necessary measures, in accordance with the applicable domestic ordinances.

Employment of agreement

Many issues exist which both governments must solve in order to execute this new agreement. The activities to be conducted under this agreement are thought appropriate for the United States and Japan, economic and S&T giants, in fields which are important for both nations and, since it is likely that they will contribute to the knowledge and technological base of the world,

Japan must act positively through such means as gaining the extensive cooperation of universities and private research institutions when appropriate. For balanced access to the concerned activities and information, the Japanese government must also improve the circulation of S&T information, increase opportunities to bring researchers from the United States, expand the fellowship system and furnish an environment to receive researchers, etc.

In any case, the conclusion of the New U.S.-Japan S&T Cooperation Agreement shall mark a step toward a new age in U.S.-Japan S&T relations, which is certain to be strengthened based on this agreement. Therefore, the understanding and cooperation of the parties concerned is expected for the smooth execution of the agreement.

The first meeting of the Joint High-Level Committee of this agreement was held in Tokyo in October 1988. A plan was set up for the execution of the agreement, which included the selection of the members of the Joint High-Level Advisory Organ. Balanced access to activities and information and proposals of cooperation themes were also discussed.

2. Strengthening Basic Research and Research Standards in Japan

What are the basic research conditions in Japan? The basic research trends forwarded by the nation and the private sector, as well as capital investment and research standards of Japan, will be discussed below.

(Measures and trends as nation)

As a nation, various policies based on the S&T Policy for the promotion of creative S&T are under development, mainly in basic research fields. Under this policy, a basic plan was set up for the R&D of S&T related to matter and materials. An inquiry was submitted to the Scientific and Technical Council by the prime minister regarding the basic plan for the R&D of information and electronics-related S&T as well as on the basic guideline to complete the base for S&T promotion. Since November 1988, an investigative deliberation has been underway.

As for national research institutes joining the universities in playing a major role in conducting basic research in Japan, Report No 13 of the Scientific and Technical Council, "Mid-Long Term Perspective of National Research Institutes" was submitted in September 1987 to create new technical seeds. Policies to strengthen basic and pioneering research and related organizations and improve their operations were set into motion.

Meanwhile, in the academic research fields mainly led by universities, the "Educational Reform Promotion Policy--Immediate Countermeasures for Educational Reform" was approved by the Cabinet in October 1987 in response to the report of the National Council on Educational Reform. As the future course of this policy, the expansion of subsidies for scientific research expenses, the fostering of young researchers, and joint research with the private sector shall be conducted along with the exchange of researchers and

promotion of international joint research to achieve academic progress and contribute to international society.

Consequently, the completion and installation of various systems for basic research have been realized (Table 1-1-3). Organizational reform and the reorganization of research institutes are also in process in order to originate innovative technical seeds, based on Report No 13 of the Scientific and Technical Council and the new demands of national research institutes.

Table 1-1-3.

(Unit: ¥100 million)

Item	1983	1988	Remarks
1. Special coordination funds for promoting S&T	62	92	
Of these:			
priority basic research	--	14	Established in 1985
international exchange for basic research	--	6	Established in 1988
2. Exploring research for advanced technology operation (ERATO)	22	38	
3. International frontier research	--	15	Established in 1986
4. Grant-in-aid for scientific research	395	489	
5. Ordinary expenditure for national research institutes	334	333	

(Trends of private sector)

In the midst of the increased globalization and structural adjustment of the Japanese economy, Japan's industrial circles are starting to operate under management with priority in technology. According to the "Survey on the Comparison of U.S.-Japan Business Behavior" conducted by the Ministry of International Trade and Industry, strengthened technical power ranked high, preceded only by achievement of the maximum profit, and higher than achievement of maximum sales, multipolarization of business activities and globalization. Strengthened technical development is also regarded as a high priority as an effective measure for increasing profits (Figure 1-1-4). Under these conditions, private research expenses are increasing progressively. An increase of over 9 percent annually in real terms has been shown during the past 5 years, in spite of wild fluctuations such as the higher yen quotation.

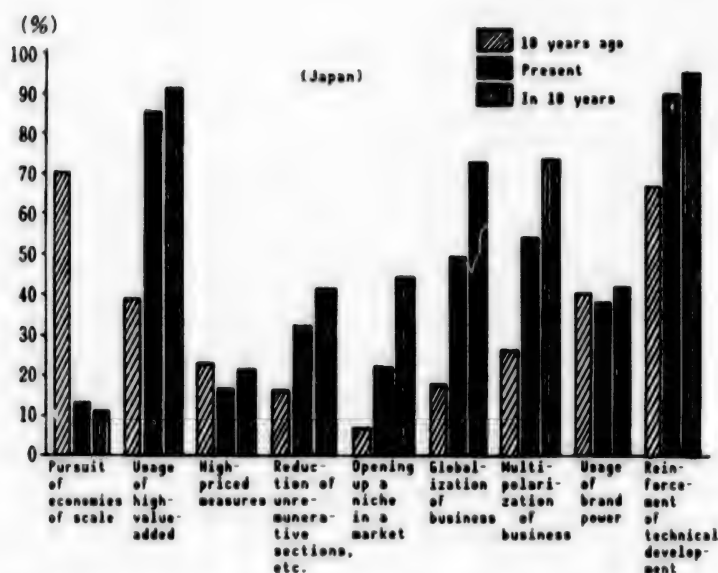


Figure 1-1-4. Most Effective Profit Making Measures
(Source: Comparative Survey of U.S.-Japan
Business Behavior" (July 1988) by MITI

Due to the increased capital investment, intense competition among enterprises in technical development, and major companies entering pioneer research fields based on long-term business strategies, R&D is becoming increasingly sophisticated, with higher emphasis placed on basic research. According to the "Survey on Research Activities of Private Enterprises" conducted by the Science and Technology Agency ("Private Trench Survey"), 38 percent of the businesses replied that they had strengthened basic research during the past 5 years, while 70 percent intend to strengthen it in the future, when categorizing their approach to basic research during "the past 5 years" and in the "future." As for the significance of basic research, 63 percent of the businesses mentioned its "importance in creating innovative technical seeds," which ranked the highest, followed by "necessary to maintain and advance technical development capacity" (55 percent) and "necessary to enter new fields for multipolarization of business management" (42 percent). Accordingly, it can be said that businesses are reinforcing basic research in search of new technical seeds for development, while maintaining the current high technical standards, in the midst of intense international competition.

Reorganized and newly installed research organs are also underway in industrial circles. According to the "Private Trend Survey," most businesses made some type of organizational improvement in the past few years. In particular, an increased number of research centers are emphasizing basic research, some of which are located overseas.

(Division of roles among industries-universities-government)

In promoting basic research, universities and government research institutes (national laboratories and research institutes which are corporations with a special status) play a great role. A considerable portion of their mission concerns basic research. On the other hand, as long as the ultimate goal of private enterprise is pursuing profit, there is a limit to their approach to pure basic research, which aims at discovering or searching for the truth inherent in natural laws and not at application. This structure is not likely to go through any considerable changes in the future.

However, higher research standards and greater capital investments have been seen in the recent industrial world in the age in which science and technology are said to be approaching each other or interacting and when the results of basic research are becoming applicable commercially at a faster pace. According to the "Survey of Pioneer S&T Researchers," which surveyed researchers in four fields, namely, life science, matter/materials science, information and electronics science and marine and earth science, the industrial world is starting to take up research to acquire new knowledge which will be useful in creating new technology (basic research pursuing seeds of technology) or research to acquire new knowledge to solve technical issues (basic research with object), although their definite applications have not yet been clarified. National research institutes are expected to play an extensive role, mainly in basic research, pursuing seeds of technology and supplying large-scale facilities, etc. (Figure 1-1-5).

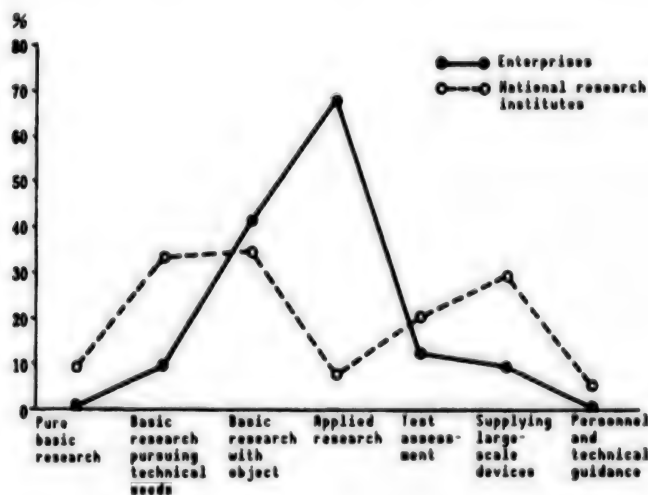


Figure 1-1-5. Allotted Roles on Research Organs
Source: "Survey of Pioneer S&T Researchers"

Accordingly, governmental research institutes must play an important role in basic research in the future.

(Investment standards in basic research)

Investment in basic research throughout Japan has increased at an annual rate of 8.9 percent from FY 1977 to 1986, amounting to a more than 2.1-fold increase in investments (Figure 1-1-6). When classified by type of organizations, industry occupied the highest share. However, since there was a marked growth in investments for applied and developmental research by the industries, the ratio of basic research expenses to total research expenses in Japan has decreased.

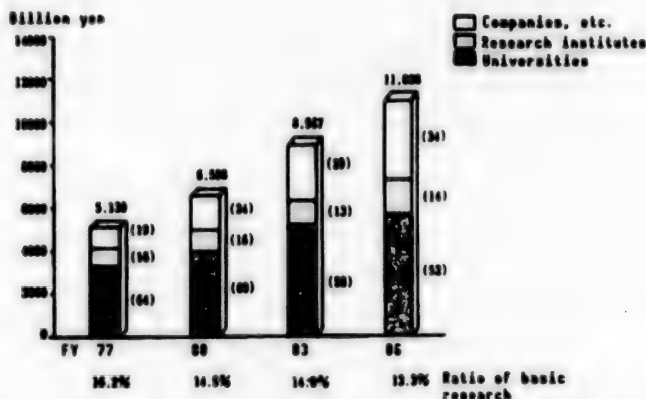


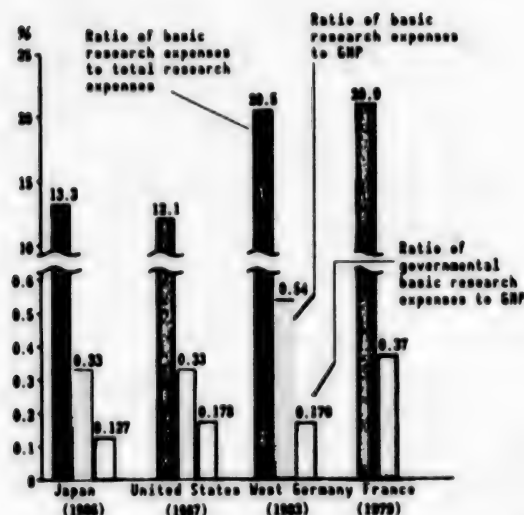
Figure 1-1-6. Basic Research Expenses by Organizations in Japan
Source: "Report on S&T Research Survey" by
Statistics Bureau, General Affairs Agency

An international comparison of basic research ratios shows that basic research accounts for approximately 20 percent of research expenses in Europe, and Japan is at about the same level as that of the United States. However, since national defense expenses, which account for a low share of basic research, accounts for nearly one-third of the total R&D expenses in the United States, the basic research ratio excluding these expenses amounts to approximately 17 percent. As for the ratio of total basic research expenses of a nation and governmental basic research expenses to the GNP, the standards are high in the Western nations (Figure 1-1-7).

(International comparison of Japan's basic research standards)

Let us view the research standards of basic research in Japan from its results, in relationship to its investment.

An international comparison of basic research standards had not previously been conducted due to the difficulties involved. In the survey of pioneer S&T researchers, basic research themes in life science, matter/materials science, information and electronics science and marine and earth science fields in Japan, the United States and Europe were compared. The results of the comparison has been analyzed, as follows (Figure 1-1-8).



Note: 1. Subject of this survey was natural science for Japan and total of natural science, cultural and social sciences for other nations.
 2. Since Japan does not employ the full-time exchange rate (FTE) as is used in universities in the Western nations, each ratio under Japan will be reduced with this method (Eg. 0.127-0.088).

Figure 1-1-7. Ratio of Basic Research Expenses by Nation
 Source: Japan: "Report of S&T Research Survey" by Statistics Bureau of General Affairs Agency
 United States: NSF Statistics
 West Germany: "Bundesbericht Forschung 1988"
 France: OECD Statistics

Comparison of United States and Japan

In the life science and marine and earth science fields, the United States was far superior to Japan (except for one theme), with more than 80 percent of the researchers recognizing this fact. Japan's technical standards in the matter and material science and information and electronics science fields were by no means inferior to those of the United States, but rather superior in some areas. However, there is a considerable gap in respect to basic research.

Comparison of Europe and Japan

On the other hand, while the gap between Europe and Japan is smaller than that between the United States and Japan in the life science, marine and earth science fields (except for one theme), Europe is still in a considerably dominant position. The standards of the matter and material science fields are generally the same or slightly higher in Europe. In information and electronic science, however, Japan is considerably superior to Europe.

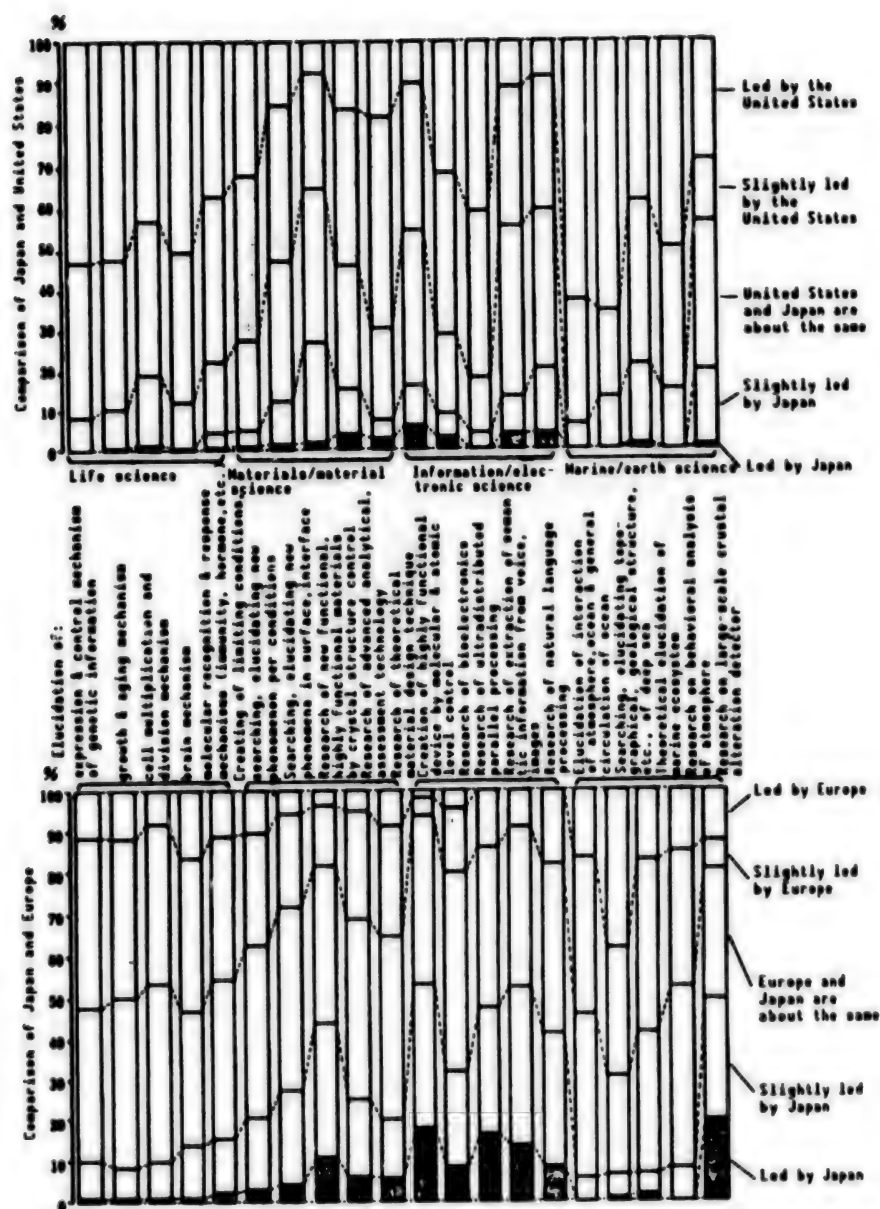


Figure 1-1-8. International Comparison of Basic Research Standards
Source: "Survey of Pioneer S&T Researchers"

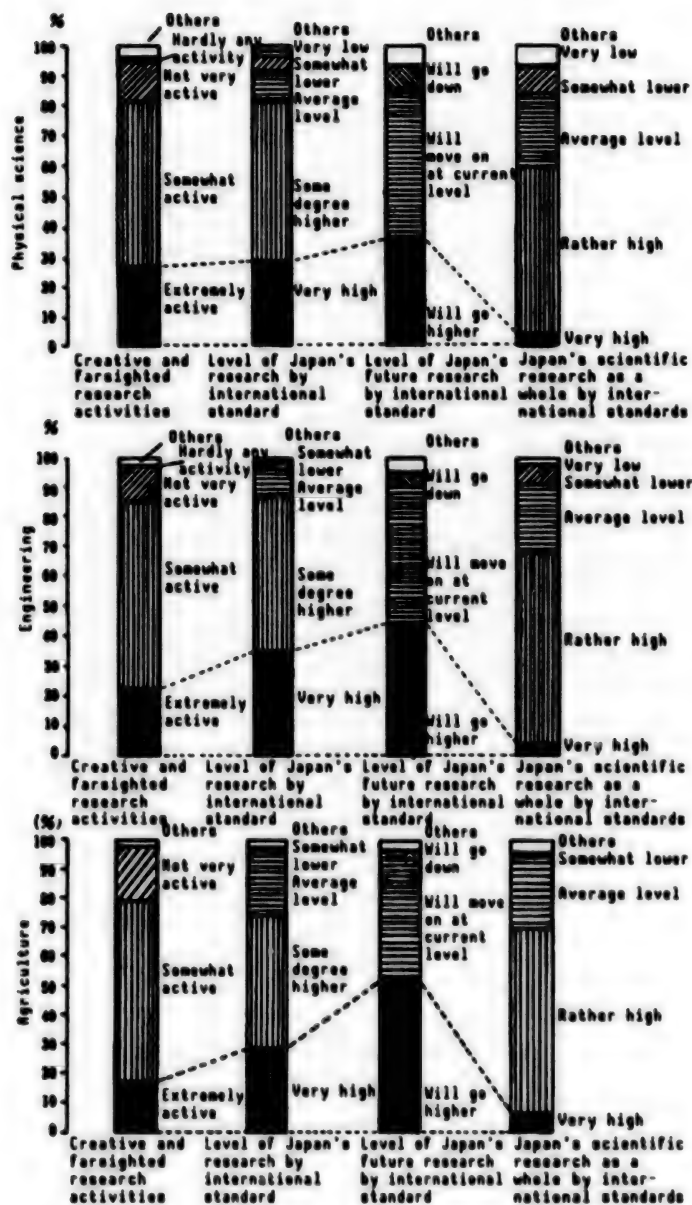


Figure 1-1-9. Assessment of Japan's Scientific Research Standards

Note: The three items other than the standard of scientific research are the assessment of respondents in these special fields.

Source: "Trends of Japan Scientific Research, Japan Science Council

Consequently, the relative standards of Japan, the United States and Europe can be assessed as follows:

(I) Life science:	United States>Europe>Japan
(II) Matter/material science:	United States>Europe>Japan
(III) Information/electronics science:	United States>Japan>Europe
(IV) Marine/earth science:	United States>Europe>Japan

If a nation's basic research standards are viewed as representing the consciousness of the researchers, Japan's current status is far behind that of the United States and is also led by Europe.

Also, let us look at the "Trend of Japan's Scientific Research" compiled by the Science Council of Japan (Figure 1-1-9) in April 1988. According to that, the scientists who see [Japan] as being extremely active in creative research are one in four in the physical science and engineering groups, and one in six in the agricultural group. In all fields, approximately 30 percent of the scientists regard the current level as very high. Furthermore, in the physical science and engineering groups, those who foresee that it will either remain at the current level or will go down in the future outnumber those who foresee that it will go higher. In the agricultural group, the number is approximately the same. With respect to the level of creative research activity and the level of Japan's research by international standards, if we add the mid-range responses of "somewhat active" and "somewhat high" to the "very active," and "very high," responses, the level of Japan's scientific research is generally high, approximately 80 percent in each field. However, as a whole, Japan is at the stage where we should strive for a higher level.

3. Improvement of Research Environment Hoped for in Japan

(Strengthening basic research)

As already mentioned, while Japan has achieved high technical standards on the international level, it is necessary to further strengthen basic research which is the base of such technology. Japan's international contribution has, in fact, been small from the standpoint of creating an outcome which brings about marked progress in the world's S&T. Basic research may profit mankind as a whole, and may also become the source of future technical innovations. In order to reinforce basic research, it is also necessary to have a potential for contributions to economic power, S&T standards, research equipments and facilities, etc. This is demanded of Japan, which has become one of the top economic and technical forces in the world. Consequently, Japan must maintain, as well as advance its potential in the application and development fields it has nurtured, strengthen basic research from a new standpoint and contribute to the expansion of the world's intellectual stock while meeting its own needs.

Accordingly, the government has begun to strengthen measures to promote creative basic research in recent years with the recognition of the large role it must play. Private enterprises, which are confronting intense

technical competition both in Japan and abroad, are also promoting basic research in order to seek necessary technical seeds on their own. Consequently, capital investment in this field has reached a high level. However, taking the actual conditions of this research into consideration, much is expected in the future.

Some believe that Japan should continue to devote itself to application and development research, in which it excels, and play a supplementary role to the Western nations. However, this is not a realistic choice considering the scale of Japan's economic and S&T activities and the accompanying responsibilities, and also from the standpoint that it must compete as well as cooperate, with not only advanced nations, but also developing nations. In any case, strengthening basic research while maintaining its application and development force is the issue currently facing Japan.

(Necessity of environmental completion)

In order to strengthen and promote basic research, the completion of various conditions which make this possible and effective is a requisite. With its cultural background which emphasizes harmony rather than creativity in society, Japan has engaged in a so-called catch-up-type research system, with priority in organization, mainly in the industrial circles. Therefore, it is necessary to either attempt harmony, in view of this tradition, or construct a completely different and new system to strengthen basic research, which largely depends on individual abilities. It is especially important to make considerable changes, from a different angle, in research organizations, research assessment, the viewpoint of research managers and the consciousness of researchers. Such changes are strongly demanded by both society and researchers.

Moreover, securing creative personnel and strengthening the research infrastructure, which includes equipment and facilities, as well as information activities, are also required.

Various environmental conditions required to promote basic research, including research operations, research personnel, research facilities and equipment and S&T information, which are considered to be priority items, are discussed in this article.

For research operations and personnel, the anticipated research management and the transition and sufficiency of research talent have been examined. The role and number of research facilities and equipment and the consolidation of wide-ranged activities in respect to S&T information have also been studied. Since these are requisites for producing creative research results, they must be examined from the standpoint of expanding them to the greatest possible extent.

(International perspective to complete research environment)

Since the world's S&T conditions and policy trends are being examined, the assumption that each nation must properly bear its share of responsibility in S&T promotion according to the nation's economic or S&T power is increasing. It is also important to maintain a balance between contributions and benefits of S&T to avoid discontent among the advanced nations. In this age of competition and cooperation, each advanced nation, including Japan, must cope with the world appropriately for its position. The completion of a research environment, such as the facilities and equipment necessary for strengthening basic research, is extremely important in such international participation. The world's S&T has been able to make progress as of this date, due to the free transfer of research performances and the active exchange of researchers. Japan is one of the nations that has benefitted the most from this free exchange of research and circulation of research performances. In order to reduce the friction rising from the S&T fields in recent years and to meet the international expectations of Japan, we must work to establish an internationally open R&D system by improving conditions for the exchange of researchers with advanced nations, supplying S&T information overseas, receiving researchers from developing nations and promoting proper technical transfers, etc.

Part 2. Promotion of Improved Creative Research Environment From the International Viewpoint

As mentioned in the last part, Japan must strengthen creative R&D, and especially /basic research, while meeting its own long-term needs and making international contributions suitable for its S&T force. Consequently, it is necessary to establish a research system for the overall basic research environment that differs from the existing application and development research systems. A research system which enables each researcher to display his individual abilities is required in basic research.

The improvement of research operations, etc., which includes the structure and system of basic research, is a significant issue facing Japan and carries considerable expectations. The reinforcement of its infrastructure, such as research equipment and facilities which are the means for research, is also a requisite. In order to strengthen such varied functions of basic research, original measures are required that take into account Japan's culture, climate and the features of recent S&T.

In this section, issues regarding research operations and personnel, R&D equipment and facilities and S&T information, which comprise the creative research environment in a wide sense, are raised and analyzed.

1. Research Personnel and System for Creative R&D

(1) Research structure and operations to promote creative R&D

While creative research results are demanded not only in basic research but also in application and development research, creativity is especially requested in basic research since its results are expected to contribute new information. Japan's excellence in a planned and controlled research operation is often said to be one of the factors which has enabled her to achieve rapid advancement in the S&T fields. However, emphasis on the promotion of creative R&D, focusing on basic research and a suitable structure, must be considered for the future. Having a different cultural background and climate regarding S&T than the West, Japan must reform the present research structure so it will be suitable for basic research.

According to a survey of frontier S&T researchers, the completion of the organization, structure and environment was raised as the top fundamental item in strengthening basic research in each of the industries, academic and governmental organs, representing an even larger issue than the securing of funds and talent (Figure 1-2-1). A strong demand exists for the present organization and structure, as well as the formation of a new structure to meet the current needs, is strongly demanded (Figure 1-2-2). In basic research, emphasis on the individual rather than an organization and respect for original ideas are required, unlike in conventional research, which was mainly devoted to application and development. The above survey results can be regarded as an indicator of such demands. Therefore, the formation of new organizations or structures in each of the industries, academic and governmental organs, or in tie-ups of these organs, is becoming important.

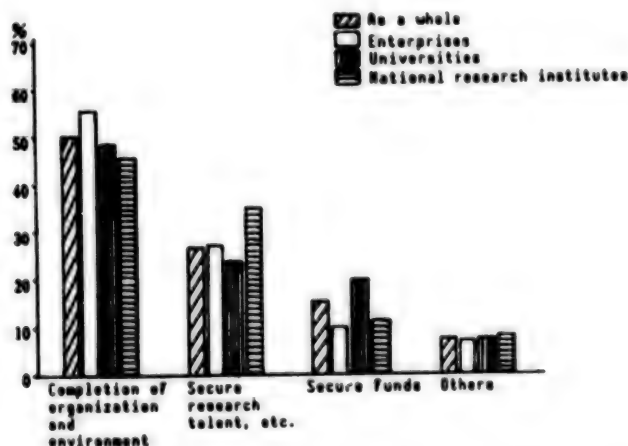


Figure 1-2-1. Basic Priority Items for Strengthening Basic Research
Data: "Survey of Frontier S&T Researchers"

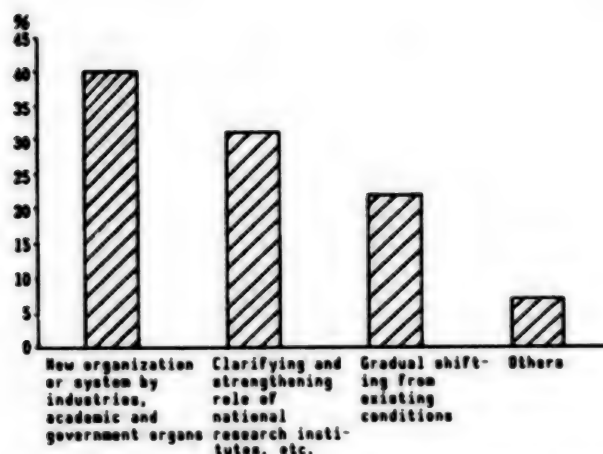


Figure 1-2-2. Ideal Organization for Promotional Basic Research
Data: "Survey of Frontier S&T Researchers"

The consciousness regarding the roles of industries and governmental organs is reflected in the recent tendency to strengthen basic research in each sector. While the role of national research organs is extensive in basic research, from the search for technical seeds to the provision of large-scale equipment, the private sector apparently is also ready to take up basic research seriously (Figure 1-1-5).

1) Reforming R&D structure

Under these circumstances, the research organization of national research institutes is being reexamined and reformed based on the "Mid-Long Term Guidelines of National Research Institutes," Report No 13 of the Scientific and Technical Council, as well as from the standpoint of strengthening basic and pioneer research, advancing its international contributions and promoting globalization of the creation of new technical seeds (Table 1-2-3). Further constitutional reform, which will take into account the functions of these organs, is demanded.

The university structure is also strengthened through the realization of joint research systems, mainly involving national universities, etc., based on reports by the National Council on Educational Reform, the Science Council, etc. In addition, recently the industrial circles have also been forgoing research conducted merely to secure and maintain the company's technical level, and instead have been emphasizing basic research to produce innovative technical seeds independently. According to a survey of the private sector's trends, 67 percent of the companies had reexamined their research organizations and recently expanded their R&D sectors, etc. Approximately 70 percent of all enterprises were planning to strengthen basic research in the future. Since establishing basic research centers while revising the company's consciousness toward basic research has been active recently, the R&D activities of private enterprises, especially for basic research, are expected to expand in the future.

Table 1-2-3. Major Organizational Reforms of National Research Institutes in FY 1988

(Hokkaido Development Council)

- Establishment of Development and Civil Engineering Laboratory of Hokkaido Development Bureau (reorganization of Civil Engineering Research Institute)

(Science and Technology Agency)

- Restructuring research organs to strengthen comprehensive research, basic research, etc. (National Aerospace Laboratory, Metallic Material Technology Laboratory, National Institute of Radiological Sciences, National Disaster Prevention S&T Center)
- Establishment of Research Institute for S&T Policy (reorganization of Resources Laboratory)

(Ministry of Education)

- Abolition of Latitude Observatory (Establishment of National Astronomical Observatory as joint organ with national universities by reorganizing Tokyo Astronomical Observatory of Tokyo University and Latitude Observatory)

(Ministry of Health and Welfare)

- Establishment of AIDS Research Center (National Institute of Health)
- Establishment of Research Institute for Agricultural Engineering (reorganization of Agricultural Civil Engineering Laboratory)
- Establishment of Raw Silk and Insects Research Institute (reorganization of Raw Silk Laboratory)
- Establishment of National Institute of Forestry (reorganization of Forestry Laboratory)

(Ministry of International Trade and Industry)

- Restructuring research organs to strengthen comprehensive and basic research (National Chemical Laboratory for Industry, Fermentation Research Institute, Research Institute for Polymers and Textiles, Geological Survey of Japan, Electrotechnical Laboratory, Industrial Products Research Institute, National Research Institute for Pollution and Resources)

(Ministry of Transport)

- Restructuring laboratory of Research Institute for Port and Harbor Technology

(Ministry of Posts and Telecommunications)

- Establishment of Research Institute for communications (reorganization of Research Institute for Radio)
-

Source: Survey by Science and Technology Agency

2) General conditions to promote creative R&D

The first factor, which concerns the individual researcher, involves having a wide intellectual curiosity and an open eye with which to observe nature, which must be acquired by education.

The second factor, an organizational factor which is the main subject of this section, concerns forming the proper R&D structure for creative research. The employment of capable personnel, the existence of research managers with an eye for accurate assessment and greater freedom in research themes, time, periods and expenses used for research are included in this factor. However, proper assessment is a requisite for the results of this research.

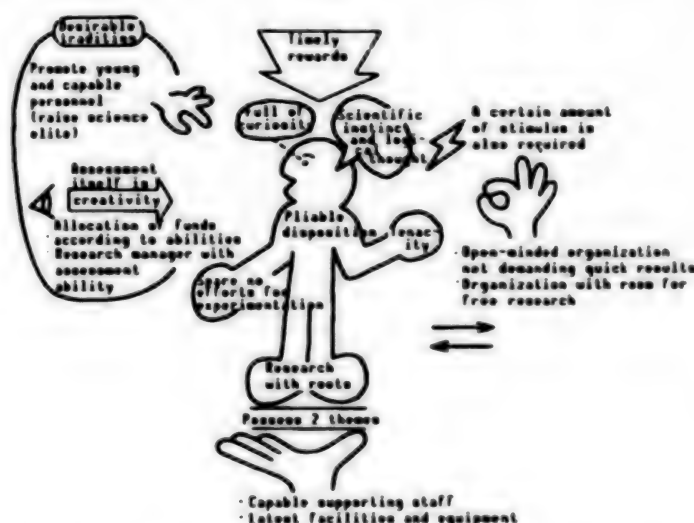


Figure 1-2-4. General Conditions for Promoting Creative R&D
Source: "Survey of Conditions for Promotion of Creative R&D"
conducted by Science and Technology Agency

The third factor is a social and cultural factor that would produce the climate for emphasizing science and advancing the social position of researchers (Figure 1-2-4).

These factors together contribute to providing a long-term creative research environment.

Table 1-2-5 shows the factors obstructing each sector's creative R&D as taken from the "Survey of Conditions to Promote Creative R&D." Especially, in respect to the organizational factor, there is a lack of research managers who emphasize original research in national research institutes. While independent research is difficult in these organs on a long-term basis, independent research itself is difficult to carry out in private enterprises.

Table 1-2-5. Obstructive Factors of Original R&D

Items	National research institutes	Private firms
Individual factors	Advanced age of researchers Few researchers capable of displaying leadership	Few unique researchers
Organizational factors	Independent research difficult from long-term viewpoint Few research managers who emphasize originality Few transfers and exchange of researchers Rigid organization	Independent research difficult Few research managers who emphasize originality Research which returns to the fundamentals is impossible
Social and cultural factors	Weak competitive spirit Low assessment of salaries, treatment, etc.	Weak competitive spirit

Source: "Survey of Conditions To Promote Creative R&D" conducted by Science and Technology Agency

3) Research environment and operations to fully utilize researchers' talents (Free research environment)

In the survey of frontier S&T researchers, "a free research environment which provides regular funds, entrusting contents and research methods to the researchers" (40 percent), and "a structure and environment enabling the proper selection of themes and assessment of research results" (17 percent) were raised as priority items from the standpoint of operating basic research. The researchers expect conditions which enable relatively free research and proper assessment to be conducted (Figure 1-2-6). While this tendency is seen strongly in researchers of national research organs and universities, and researchers of private enterprises have stronger demands for a structure which conducts the proper selection of themes and assessment, which is about the same as "a free research environment."

(Operation of Major Governmental Basic Research Systems)

Under the above circumstances, the government has successively established research systems, such as Exploratory Research for Advanced Technology, the International Frontier Research System, etc., for the promotion of basic research and has carried out research operations which meet the respective needs.

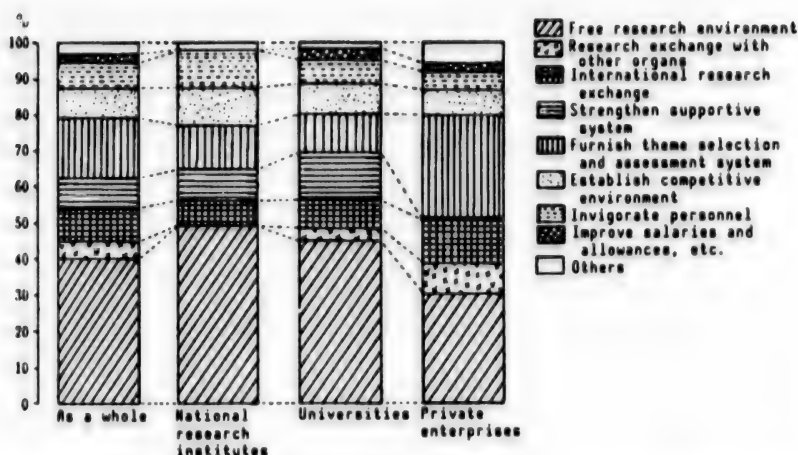


Figure 1-2-6. Priorities in Promoting Basic Research

Exploratory Research for Advanced Technology is a "man-centered" system which takes into account the individual abilities of first-rate researchers and employs a mobile researchers system. The project leader has extensive discretionary power regarding the research contents, operation and composition of researchers. Researchers are gathered from various industries, academic organs, governmental organs and organizations abroad, and research facilities of enterprises and universities are borrowed so that the research can be conducted.

The International Frontier Research System gathers researchers in various fields to conduct intensive studies of research fields which are difficult to handle by conventional research organizations. It aims at finding new scientific knowledge which may become the base of technological innovations hidden in interdisciplinary fields. Its research term is 15 years, as a rule, and the research group and researchers are replaced every 5 years. Since approximately one-third will be foreign researchers, there are currently 4 foreign team leaders among the 10 research teams.

In FY 1985, the Priority Basic Research System was established by the Special Coordination Funds for Promoting Science and Technology. It aims at promoting research which produces important technical seeds and which cannot be conducted at the ordinary research level. The selection of research themes, apportionment of research expenses, etc., are determined by the head of each research organ, as a rule. This system enables the head of each research organ to fully display his discretion and improve the research operation involving increased activities of the individual research organ based on the respective conditions. This system has been evaluated highly for its contribution to making possible the operation of a flexible organization and the flexible usage of funds, which are required in promoting basic research.

In FY 1988, the International Exchange for Basic Research was started with the Special Coordination Funds for Promoting Science and Technology in national research organs. Personnel outside the ministries have also been gathered from abroad to work under capable research leaders.

Meanwhile, national research organs are also conducting reforms and reexaminations of their research organizations on their own, based on Report No 13 of the Science and Technology Council. A comparison of the management of basic research with that of application and development research in national research organs shows that many of the differences occur from the fact that the former research puts priority on man (Table 1-2-7). In order to realize smooth research operation, 1) discretion by the head of the research organ, 2) research assessment according to the research caliber, 3) morale building of researchers, 4) research exchange, and 5) securing

Table 1-2-7. Management of Basic Research and Applied/Development Research in National Research Institutes

Item	Basic research	Applied/development research
Basic concept of management	Man-centered management Emphasis on individual researcher's idea or concept, principal object is creation of technical seeds	Organization-focused management Limited research theme is studied effectively and organizationally, according to research plan and limited administrative needs
1 Research theme	Theme set up based on individual concept Decentralized research theme Overlapping research subject admitted	Theme set up based on administrative demand Concentration on required research
2 Research assessment	Emphasis on assessment, which gives freedom in research and increases inclination to research	Emphasis on prior assessment of research plan goal
3 Researchers	Creative, and especially young, researchers	Researchers capable of steady research according to research plan
4 Research funds	Grant funds to research from standpoint of individual researcher Budget granted to researcher with inclination to display creativity Mobile research funds secured applicable at the discretion of the head of the organ	Grant research funds from standpoint of theme or organization Budget totaled according to contents of research plan

Source: Science and Technology Agency

researchers, circulating researchers and conducting personnel operations in consideration of life stages are required, as mentioned in this report.

(Research operation in private sector)

Private enterprises have been promoting R&D mainly in the application and development fields, which can be said to have the top standards in the world. These R&D activities, as well as the management based on a strong organizational power which has made them possible, are highly evaluated. On the other hand, Japan is far behind the United States and Europe in every aspect of basic research concerning research leaders, assessment systems, research environment, etc., in the operation of creative basic research, according to the "Private Trend Survey." However, the central research centers and basic research centers of the respective companies are executing their own unique efforts to achieve original results while increasing basic research activities. According to a study of the operational conditions of the major research centers of some enterprises engaged in basic research (Table 1-2-8), the following are some common factors:

- 1) Man-centered research operation
- 2) Priority on finding and training talented personnel
- 3) Research groups for each theme and organizational operation with high degree of freedom, such as inputting priority research resources
- 4) Promotion of research interchange, such as exchanging researchers in different fields

These factors demonstrate the efforts being directed toward a different type of structure than the conventional system.

The average age of researchers in basic research centers, etc., is in the early thirties, which coincides with the age group that is believed to produce the maximum outcome in basic research. This young age for researchers is being maintained by personnel exchanges with other R&D sections. In private enterprises, researchers are often transferred to other divisions or outside research-related organizations after having devoted a certain period to research in order to maintain an activated research organ through appropriate personnel rotation. Fewer than one-third of the researchers continually conduct research until they reach retirement age (Figure 1-2-9).

In research management, high-level judgment is necessary to promote researchers with creativity and have them engage in original research for producing new technical seeds and leading to application research with definite objects, under the recognition that basic research is man-centered. In private enterprises, the results of research ultimately become the product of the company. Therefore, a management system which joins the results of basic research with application and development research or the manufacturing

Table 1-2-8. Research Operation of Basic Research Centers of Private Enterprises

Firm A (electricity)

Object of basic research	Create business seeds for 21st century Promotion of research based on free ideas of individual rather than research theme
Organizational features	About 90 researchers Approximately 0.6 percent of company's total research monies spent Group leader under head of research center without middle managers Flexible group composition
Research operation, research plan, theme set up, etc.	Basic research promoted in two stages; first, researchers freely search for theme, then a research plan is set up as the idea is fixed and budget becomes necessary Research group composed of one leader and about two other researchers Researchers suited for basic research are carefully selected About a dozen researchers from Western nations Free meetings with outsiders Supporting researchers to continue basic research is important, talent is the point in basic research

Firm B (electricity)

Object of basic research	Mainly basic research with definite object Some long-term projects with high risk and outcome in 21st century Create top level originality in world
Organizational features	About 50 researchers in basic research with average age of 33 containing 10 percent of research center's resources spent for above basic research Research leader can receive applications for researchers
Research operation, research plan, theme set up, etc.	System which enables head of research center to assess researcher's plan without going through middle manager Under-the-table research to heighten researchers' will Research teams of up to about 10 members possible Expectations of pairing researchers with those from different cultures Top level information is required for top level research, many occasions to present reports and business trips abroad required [continued]

[Continuation of Table 1-2-8]

[Continuation of Firm B (electricity)]

A few researchers from Western nations
Chances provided for personnel from different fields
to meet and hold discussions
Hypothetical setting ability demanded of researchers

Firm C (chemical)

Object of basic
research

Basic research with definite object, search study

Organizational
features

About 160 researchers, average age of 34

Research operation,
research plan,
theme set up, etc.

Mainly bottom-up research themes
Conducted as underground research to some extent
since basic research assessment is difficult
About 20 percent of operation is freely conducted by
researcher
To supplement this, a system is set up to inspect the
ideas
Since researchers tend to drift to development/
application research, a research center solely for
basic research is established to prevent this
Joint research with universities promoted
Outcome of the center depends on the amount of
personnel who can freely propose challenging themes

Firm D (electricity)

Object of basic
research

Create technical seeds, new information, new
concepts for next generation, supply technical seeds
to other inner research centers
Strengthen individual studies rather than
organizational studies, priority on talent

Organizational
features

About 200 researchers in groups (about 10 each),
theme set up by leader
System provided for contract researchers
Personnel of different cultures invited, emphasis on
search for interdisciplinary, boundary fields

Research operation,
research plan,
theme set up, etc.

Considerable freedom for researchers by bottom-up
selection of research theme
This freedom is required to encourage researcher's
will and talent
Most research teams composed of 1-3 persons
Emphasis on meetings with outside organs

[continued]

[Continuation of Table 1-2-8]

Firm E (biology)

Object of basic research	Extra-high-standard research results Emphasis on cooperation between specific fields Good connection from basic research to application research
Organizational features	About 160 researchers Various technical offices Untitled offices for new fields Postdoctoral researchers employed as special researchers (2 years)
Research operation, research plan, theme set up, etc.	Bottom-up selection of research themes Office composed of 4-5 persons, about 2 persons to a team Research plan for 3-year term, reviewed by annual assessment by presenting reports, etc. Many meetings held with other research organs Many foreign researchers (many stay for 1-2 years as visiting researchers)

Source: "Survey on Revision of Research Operation for Basic Research Promotion in Japan" conducted by Science and Technology Agency

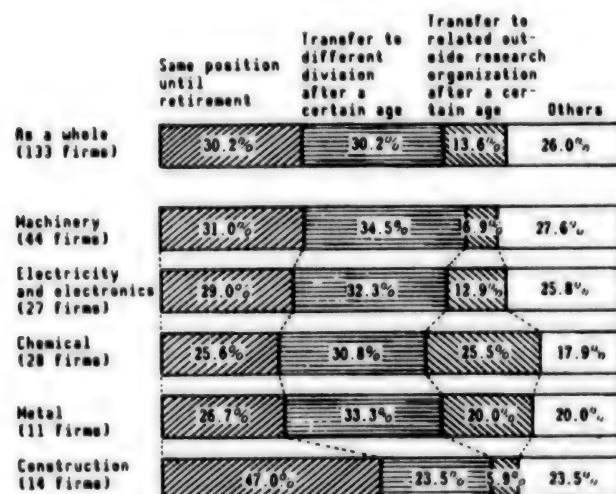


Figure 1-2-9. Treatment of Aging Researchers

Source: RESEARCH, TECHNOLOGY, PLANNING, Vol 13 No 1, 1988, of Research and Technology Planning Society

of products is expected to enable those conducting basic research to devote themselves to research. This is also viewed as a large factor supporting superior research performances. It is basically the same as giving the researchers relatively large freedom, and can be thought of as a characteristic of basic research management in private firms.

From the management side, researchers capable of proposing new research themes and with ambitious attitudes are especially demanded. Many firms are introducing a system which allows a researcher to use relatively small research expenses freely when a new idea or concept is acquired. This is regarded as an appropriate system for basic research with a relatively long research period which may be approved as an official research theme and for which full-scale research may be started in a few years.

From the standpoint of internationalization, such research centers are actively receiving foreign researchers. Many of them are also offering guidance to influential researchers from inside and outside Japan.

While these efforts are being made by the government and private enterprises, there is no typical method for conducting creative research which is mainly composed of basic research. Many types of operating methods can be explored according to such factors as R&D characteristics, research field, and status of research personnel. Therefore, it is necessary for each research organ to establish an operating system that is appropriate for its situation.

4) Research assessment

(Research assessment in Japan)

The proper research assessment method, which is extremely important when conducting research, is demanded by both the research managers and researchers. Its importance has been recognized in Western nations from early on in the management of large-scale research projects, etc. It has been conducted in various forms, according to the characteristics of each organ. It is also being carried out in material and immaterial forms in Japan, during budget drafting and distribution and while promoting individual research projects.

However, it has not necessarily been acclimated to the research climate in Japan due to the lack of experience of research assessors, a sense of resistance against assessment solely from a research manager's viewpoint, the low mobility of researchers due to the lifelong employment system, etc. In order for the sound advancement of basic research to be realized, research assessments with new viewpoints, such as giving further incentives to the researchers or promoting researchers and research to a higher level and covering a wider range, from the selection of research themes to the application of its outcome, are becoming necessary as an important aspect of research operations.

(Guidelines for research assessment)

The Research Assessment Guidelines Committee was established as part of the Policy Committee of the Scientific and Technical Council which produced the "Guidelines for Research Assessment" in September 1986. It presents the basic concept of an appropriate research assessment, necessary for promoting the nation's R&D, and also describes examples of research assessment systems using, as a model, the R&D being conducted in national research institutes. The following four items were listed, as the basic concepts to be fulfilled by a research assessment system:

- 1) Effectiveness: Effective functioning in research, such as giving useful advice to researchers through the research assessment process, is required. Its results must be reflected in the actual decision-making.
- 2) Continuity: The continuity of research assessment in a regular system is required for effective functioning.
- 3) Flexibility: Flexibility is required in a research assessment system in order to cope properly with the diversity of R&D and with the various conditional changes in research.
- 4) Transparency: The concept, method, etc., of the research assessment must be clearly indicated to the researchers in order for it to be consistent.

According to these guidelines, urging the researchers to bring out new ideas and using research assessment as a means of advancing creative research is the most important aspect of the assessment of basic research. A research assessment system which emphasizes the intellectual union between the researchers and assessors should be constructed and operated to provide suggestions for the promotion of research. Further development of this research assessment based on the guidelines is anticipated in each research organ.

(Assessment of basic research)

A survey was conducted on how research themes are assessed in national research institutes and private enterprises (with capital of over ¥20 billion) when starting basic research (Figure 1-2-10). A total of 36 percent of the national research institutes and 30 percent of the private enterprises indicated having "no regular assessment of research themes conducted in general" (some form of assessment is conducted). The most numerous reply was "regular assessment of research themes conducted for basic research as well as for other research," which amounted to 53 percent for the national research institutes and 44 percent for private enterprises. New measures can also be seen, with 16 percent of the private enterprises replying that a "special assessment method" for basic research themes is being practiced.

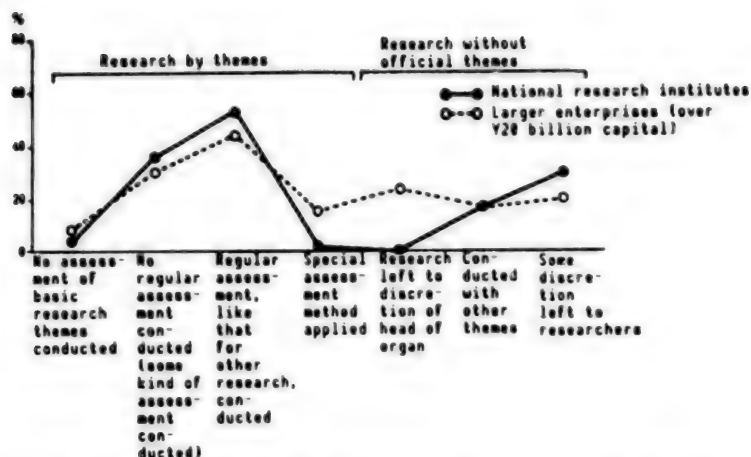


Figure 1-2-10. Assessment Method for Starting Basic Research
Source: "Survey of Improvement of Research Operation for Basic Research Promotion in Japan" conducted by Science and Technology Agency

On the other hand, basic research is conducted without an official theme in many cases, with 30 percent of the national research institutes leaving it to the "researchers' discretion." As for private enterprises, 23 percent "conducted research at the discretion of the head of the organ," while 16 percent "left a certain discretionary power to the researchers."

The reason for many organs with regular assessments also conducting basic research according to themes may be due to the lack of a clear and general assessment method and the fact that each organ had a different concept of basic research.

The main items checked at the intermediate assessment level by national research institutes and private firms concerned the output and the degree of progress, such as the "output of research" and the "progress of the plan." There was a sharp reduction in items expected to be checked, such as "progress of plan," but instead, items such as "enthusiasm of researchers" and "problems in future research," which emphasize the researchers' enthusiasm or will, increased. The strong prospects for improving the assessment concept can be regarded as a desirable direction (Figure 1-2-11). The frequency at which intermediate assessment is conducted was generally indicated as being on an annual basis.

Assessment from the standpoint of raising capable researchers is generally still lacking in Japan's basic research field. This is an issue that should be resolved in the future.

The assessment of the selection of basic research themes to be subsidized by the government will be increasingly important in the future, accompanying the increase in basic research. In the United States, for example, where research assessment is widely conducted for from large-scale projects to basic research fields, efforts are made to conduct accurate assessment in accordance with the respective objectives. It is necessary that each

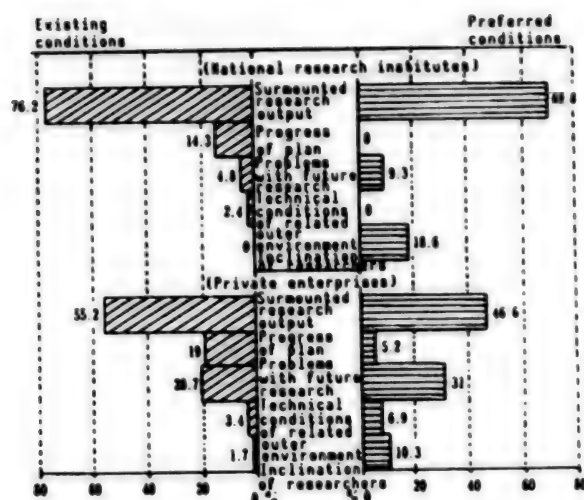


Figure 1-2-11. Intermediate Assessment Issues of Basic Research
 Source: "Survey of Revision of Research Operation for Basic Research Promotion in Japan" conducted by Science and Technology Agency

research organ in Japan make every effort to advance research assessment as well.

5) Cooperation and research exchange among industries, universities and governmental institutions

(Rising necessity for cooperation)

With the recent more advanced, complex and expanded R&D in borderline and composite fields, the importance of active research exchange and interdisciplinary and cross industrial approaches have come to be highly recognized in the promotion of creative R&D. When the researchers meet with researchers representing other fields and organizations, they receive intellectual incentives which may lead to the development of new ideas. This is also meaningful from the standpoint of research operation and represents an important means of transferring the research results of governmental research institutes and universities to private firms. Therefore, the government has taken measures to improve the legal problem involved in promoting research exchange, such as enacting the Law for the Promotion of Research Exchange in May 1986 (enforced in November of the same year).

According to the Science Council of Japan's "Academic Research Trends in Japan," the higher the international standards for research activities involving the natural science division, the greater the weight exerted on joint research and closer relationships among industries, universities and government institutions are found.

(Research exchange conditions)

Government research institutes have been developing several measures for use in expanding research exchange. The number of joint research projects between private enterprises and universities, etc., by the Science and

Technology Agency, Ministry of Agriculture, Forestry and Fisheries, and Ministry of Construction increased sharply, from 154 cases in FY 1984 to 290 cases in FY 1986. Taking into account the conventional joint research, which remained at the allotted research level, the ministries and agencies started a "Government-Industries Special Joint Research System" in FY 1985 to promote large-scale joint research, which has been relatively difficult to conduct, through the exchange of researchers and the joint usage of facilities and equipment (Table 1-2-12).

Table 1-2-12. Conditions of Government-Industry Joint Research

Fiscal year	1985	1986	1987	1988
Number of themes	6	12	18	32
Budget (¥ million)	157	355	489	547

Notes: 1. Total of four ministries and agencies (Science and Technology Agency, Ministry of Agriculture, Forestry and Fisheries, Ministry of International Trade and Industry, Ministry of Construction) employing this system.

2. Original estimate used for budget.

Source: Surveyed by Science and Technology Agency

Research exchange is one of the keynotes of the above-mentioned International Exchange for Basic Research System, etc., covered by the Special Coordination Funds for Promoting Science and Technology, since it gathers researchers from various fields outside the research organization, including some from overseas.

In order for researchers to be permitted to participate in research meetings, which is a requisite for acquiring and announcing the latest research information, Article 4 of the Law for the Promotion of Research Exchange (release from duties for participation in research meetings) was enacted. A total of 3,299 researchers have taken advantage of this law since its enforcement (as of 1 June 1988).

Of these, 2,601 researchers have participated in research meetings in Japan and 698 researchers have participated in research meetings abroad.

Joint research between universities and private enterprises, etc., increased sharply after the "Joint Research System With the Private Sector" was established in FY 1983. FY 1987 produced 396 research cases and 465 invited researchers (Figure 1-2-13). As for category, there were many research themes in the materials, material and biotechnology fields. There were also many themes related to research equipment development, such as electronic microscopes, etc. Consigned research, entrusted by private firms and conducted by researchers at national universities, etc., as official duties (1,814 cases amounting to ¥3,900 million in FY 1987) and consigned researchers providing guidance at the graduate school level (914 persons in FY 1987) are also growing steadily in number.



Figure 1-2-13. Joint Research Between Universities and Private Firms, Etc.

Source: Survey by Ministry of Education

Moreover, the joint research centers, facilities for research cooperation between universities and the industrial world, including joint research by industries, academic and governmental institutes beyond the framework of departments and divisions, were established in three universities in FY 1987, followed by five universities, including Tokyo Agricultural Engineering University, in 1988.

According to a survey of private trends, the largest number of researchers employed by private firms went to national universities (33 percent of all researchers sent to other organs, 882 in number), followed by 661 persons to other private firms, etc. (24 percent) and 463 persons to national research institutes (17 percent). In addition, 80 percent of the visiting researchers were from other private firms, etc., totaling 390 persons (Figure 1-2-14). Accordingly, private enterprises have the distinction of sending researchers to universities and official organs while receiving researchers from other private firms. A comparison with a survey conducted by the Science and Technology Agency in FY 1978 shows that the share of research exchange with national research institutes has increased, while the share with other private firms has decreased.

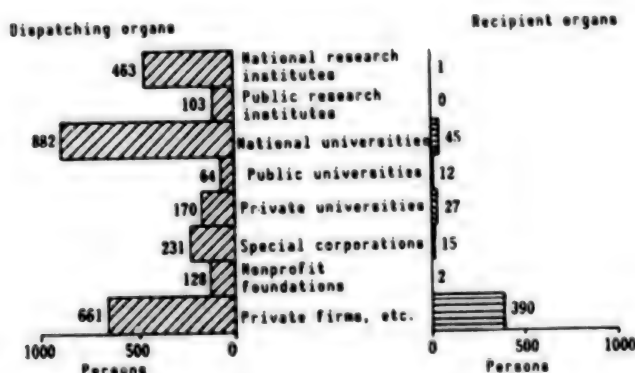


Figure 1-2-14. Dispatching and Recipient Organs of Researchers From Private Firms

Source: "Survey of Research Activities of Private Enterprises (1988)" conducted by Science and Technology Agency

In research execution, few companies conducted both overall R&D and basic research independently. Most companies made use of outside organs in some form, such as consigned or joint research. These outside organs consist mostly of universities and government research organs for basic research and companies engaged in different businesses when other private firms are involved. When universities or governmental research organs are used for basic research purposes, many firms entrust research or conduct joint research with the universities, while government research organs often become joint research partners or act as an organ sending or receiving research personnel.

(Exchange of researchers with other nations)

The international exchange of researchers and joint research are extremely effective for opening up new research frontiers for new discoveries and ideas. In order to realize an internationally open research system and to cope properly with international circumstances, efforts to promote such exchanges are becoming necessary.

In respect to the exchange of researchers abroad, national research institutes have seen an increase in both the dispatched and visiting personnel, although there are still more dispatched researchers than visitors (Figure 1-2-15).

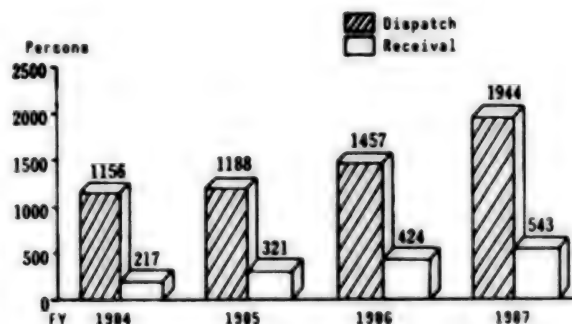


Figure 1-2-15. Dispatch and Receipt of Researchers With Overseas Nations by National Research Institutes

Notes: 1. Dispatch and receipt for technical cooperation not included.
2. Includes attendance at international research meetings.

Source: Survey by Science and Technology Agency

According to the "Fact-Finding Survey Concerning Research Exchange in Private Enterprises" conducted by the Science and Technology Agency, the approximately 600 private firms that replied to the survey reported that private firms in Japan dispatched 561 persons to overseas organs, while 360 persons visited from abroad.

Such exchanges of researchers with overseas organs are expanding in various fields, although there is currently an imbalance between the number of researchers dispatched and received.

Due to circumstances, the government has established a fellowship system to receive foreign researchers, starting in FY 1988, using the Special Coordination Funds for Promoting Science and Technology and the Expenses for Foreign Researchers, in addition to the conventional system for receiving foreign researchers conducted by related ministries and agencies. Through this fellowship system, Japan expects to receive approximately 110 researchers through national research organs and approximately 100 researchers through universities, etc., during the first year. Further efforts are anticipated to promote the balanced exchange of researchers with overseas organs.

Upon receiving foreign researchers, various issues regarding the environment during their stay, such as housing, etc., cannot be neglected. Not a few foreigners feel "uneasy about the living environment" when participating in R&D activities in Japan. An increase in organizations and opportunities to teach Japanese, the furnishing of accommodations, and steady and proper publicity measures and activities overseas are commonly required before foreign researchers can be invited.

(2) Securing creative researchers

The importance of creative researchers is increasing in Japan, with strengthened basic research and business management being given technical priority. The trends of researchers in Japan, along with a comparison with overseas nations and the conditions need to secure research personnel, have been examined.

1) Structure and international comparison of researchers in Japan

(1) Number of researchers

R&D activities are conducted by researchers, research assistants, technicians, research clerks and other support personnel. According to an S&T research survey report by the Statistics Bureau of the General Coordination Office, 692,000 persons are engaged in natural science research in Japan, 418,000 of which are researchers.

The number of researchers in Japan has been steadily increasing, without being influenced by the economic situation since 1965. Its scale in 1987 was 3.6 times that of 1965 in the natural sciences division (3.3 times if cultural and social sciences are included), which is a large growth compared to that of other nations. This has contributed to marked advancements in Japan's S&T standards (Figure 1-2-18).

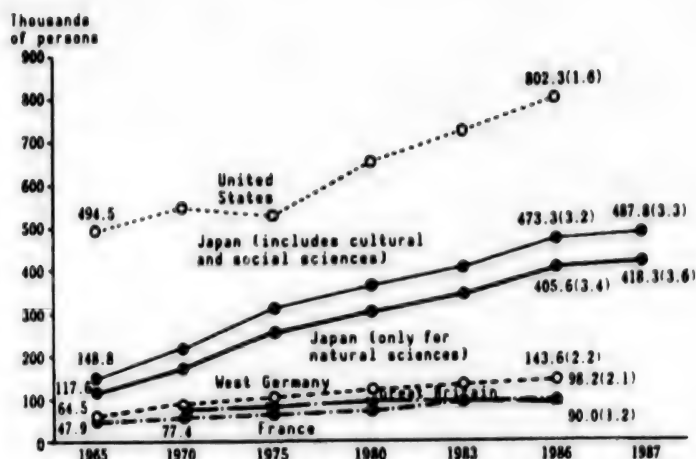


Figure 1-2-18. Transition of Number of Researchers in Major Nations
Source: Gathered by Science and Technology Agency

As for the share of the number of researchers in the OECD member nations as compared to the total number of researchers in OECD, the United States has the largest share at 42 percent, followed by Japan with 25 percent of the total.

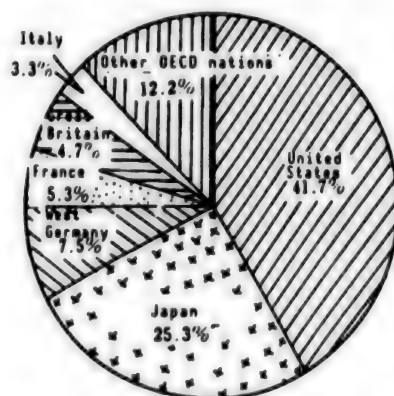


Figure 1-2-19. Distribution Ratio of Number of Researchers in OECD Nations

Source: From "Janesco's 1987 Cultural Statistics Annual," etc.

Since Japan's share surpasses that of West Germany, France, Great Britain and Italy, it has attained a very high position, even when comparing the number of researchers (Figure 1-2-19).

(Steady growth of researchers in private firms, etc., in Japan)

With respect to the number of researchers in Japan by category, more than 60 percent of all researchers (261,000 persons) are employed by private enterprises, which has grown markedly to more than twice the number of researchers in universities (124,000 persons). This reflects the private sector's favorable economic activities in the midst of severe conditions caused by the recent higher yen quotation. Private firms are inclined to

emphasize R&D to cope with the intensifying competition in technology on an international scale and as a strategy for industrial globalization and advancement into different industries (Figure 1-2-20). Reflecting such vigorous efforts in R&D by private enterprises, their share increased further to 62.4 percent, in FY 1987. In comparison to the number of researchers 5 years ago, the growth rate is extremely high, at 35.2 percent (68,000 persons).



Figure 1-2-20. Transition of Number of Researchers in Natural Science Sector (1982=100)

Note: "Companies, etc." and "universities, etc." in the S&T Research Survey are indicated as "companies" and "universities" (etc.).

Source: "S&T Research Survey" by Statistics Bureau, General Coordination Agency

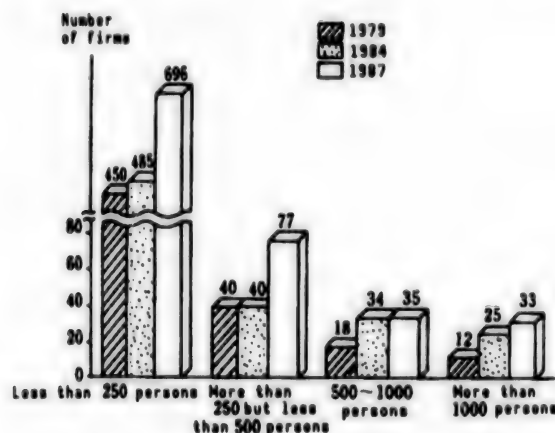


Figure 1-2-21. Transition of Private Firms by Number of Researchers

Note: Data for December applied for each year.

Source: "Survey of Research Activities of Private Enterprises" conducted by Science and Technology Agency

The scale of research organs of major firms in Japan is also expanding due to the recent increase in researchers. Firms employing more than 1,000 researchers which replied to a private survey of trends numbered only 12 in 1979, but increased to 33 in 1987 (Figure 1-2-21). Since there are currently 4 companies with close to 10,000 researchers, research organs of private enterprises in Japan can be said to have come to rank with the leading Western firms.

(Researchers in national research institutes)

Researchers in national research institutes in 1987 numbered 10,016, which is an increase of 39 since 1982, 5 years ago. Its share of the total number of researchers in Japan has decreased, from 3.1 percent in 1982 to 2.4 percent in 1987. It is indicated in Report No 13 of the Science and Technology Council that strengthening basic and frontier research to create new technological seeds, etc., and sufficient international contributions are especially important roles of national research institutes. Therefore, it is necessary to revise its research structure, placing special emphasis on basic research.

(ii) Researchers by field and organization

The number of researchers in Japan has been steadily increasing annually as a whole. Looking at the distribution ratio of the respective fields, the share of the engineering group increased from 44.1 percent to 46.6 percent in 10 years, while the number of researchers in the science group increased from 66,000 in 1977 to 91,000 in 1987, and that in the agriculture group increased from 23,000 to 28,000 during the same 10 year period. While this is an increase of 25,000 and 5,000 researchers, respectively, contrary to the engineering group, their shares have decreased from 24.3 percent to 21.8 percent for the science group and from 8.5 percent to 6.7 percent for the agriculture group. In order to cope with the increased demand for technical personnel in the private sector, the number of researchers in Japan has increased, mainly in the engineering group, while to a relatively lesser extent in the agriculture groups (Figure 1-2-22).

Looking at the researcher transition, by organization, in the major nations, the private sector share has sharply increased in Japan, the United States, and West Germany as a result of active R&D activities by private enterprises. Conversely, the ratio of government research institutes has decreased.

On the other hand, the share of government research institutes is higher in France than in Japan, the United States and West Germany, as they have been the leaders in France's tradition of basic research (Figure 1-2-23).

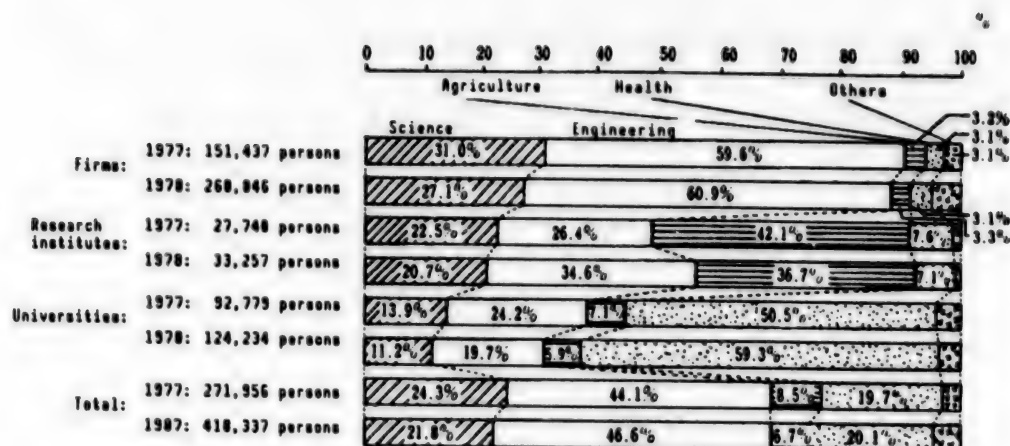


Figure 1-2-22. Transition of Researcher Distribution Ratio by Field

Source: "S&T Research Survey" by Statistics Bureau, General Coordination Agency

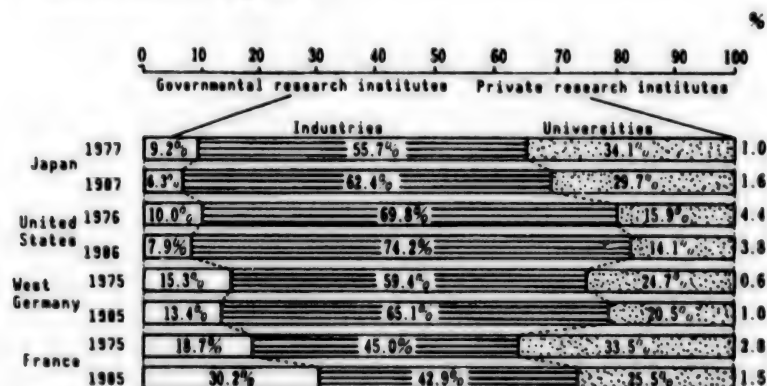


Figure 1-2-23. Distribution of Number of Researchers by Organizations in Major Nations

Source: Produced from attached material No 5

In Japan, greater importance is placed on national research institutes in terms of strengthening basic and frontier research. By doing so, they are aiming at creating innovative technical seeds and competing successfully on the international level.

With respect to the researchers in governmental research institutes (including researchers employed by corporations with special status in Japan and Europe), the number of researchers in Japan is about the same as that in West Germany and Great Britain, while the United States and France have approximately 5 times and twice the number of researchers of Japan, respectively (Figure 1-2-24). These nations possess internationally influential governmental research institutes such as the National Institutes of Health (NIH) of the United States, the Max Planck Scientific Promotion Association of West Germany and the Centre National de Recherche Scientifique (CNRS) of France, which play important roles in promoting basic research, training of personnel and forwarding international cooperation.

(iii) Age distribution of researchers

In regard to the age distribution of researchers, 53 percent of the researchers at private enterprises (in 1987) were under 35, due to an established system which transfers researchers above a certain age to other divisions or outside research organizations (Figure 1-2-9). On the other hand, only 23.9 percent of the researchers at national research institutes were under 35 (in 1986). According to a survey by the National Personnel Authority, the average age in these institutes was markedly higher than that in private firms, at 42.8 (in 1988).

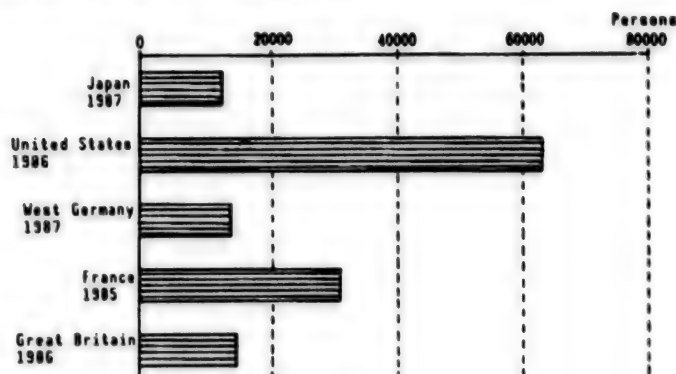


Figure 1-2-24. Comparison of Number of Researchers in Governmental Research Institutes of Major Nations
Source: Science and Technology Agency

Since a survey of frontier S&T researchers indicates that the age group most likely to yield an outcome in basic research is the early 30s, research institutes of private firms can be expected to have high creative potential (Figure 1-2-25).

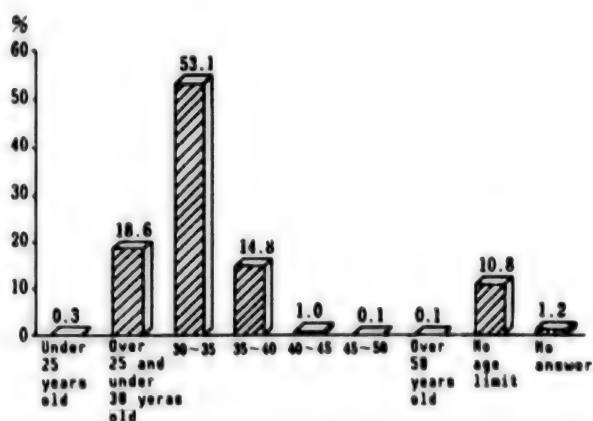


Figure 1-2-25. Age Groups Expected To Achieve in Basic Research
Source: "Survey of Frontier S&T Researchers"

Looking at the age distribution of researchers (excluding universities) in the major nations, the average age is relatively high in the United States, West Germany and France, while a slight difference is shown in the annual survey.

The higher average can be regarded as resulting from a research operation which places priority on the individual over the organization. Due to the sharp increase of young researchers in the private sector, researchers under 35 amount to approximately half of the researchers in Japan. This can be said to have contributed to the advancement of Japan's technical standards and the strengthening of its international competitiveness, particularly in the private sector (Figure 1-2-26).

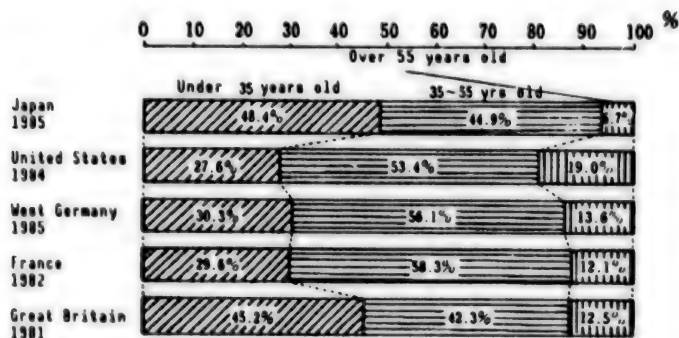


Figure 1-2-26. Age Distribution of Researchers in Major Nations (Excluding universities)
Source: "Science and Engineering Indicators--1987" by NSB of the United States

(iv) Number of degree holders

The number of degree (master's and doctoral degrees) holders has been changing due to various social factors and needs, such as changes in the industrial structure, changes in the school-age population and an increase in the population with higher education. Looking at the degree holders (master's and doctoral degrees) in the natural science fields in Japan, the number of persons with master's and doctoral degrees, who are regarded as comprising the highest ratio of those entering a research profession, was 15,058 and 7,688, respectively, in 1986. This is an increase of 6,164 persons (69 percent increase) and 3,270 persons (74 percent increase) during the past 10 years.

The number of degree holders in the science fields who demonstrate a high tendency to take up basic research has grown from 2,158 persons to 2,993 persons (for both the master's and doctoral degrees) during the past 10 years, which is an increase of 835 persons (approximately a 39 percent increase).

Comparing the number of degree holders (master's and doctoral degrees) in the science, engineering and agriculture fields of four nations--Japan, the United States, West Germany and France--the United States has the highest

share, with 56,741 persons, approximately three times the number in Japan, followed by 17,042 in Japan, 10,100 in Great Britain and 4,658 in West Germany. The United States is far ahead of the other nations, except in the agriculture fields. Japan has a large share of degree holders in the engineering fields and the least number in the science fields, although it ranks high in the agricultural fields. Degree holders in science have the largest share in West Germany, as they do in Great Britain, followed by those with degrees in engineering (Figure 1-2-27).

Comparing the number of doctorate holders in science and engineering in the United States and Japan, there are 860 persons in Japan versus 7,438 persons in the United States in the sciences and 1,404 persons versus 3,236 persons in the engineering fields, showing Japan has approximately one-ninth and one-third that of the United States, respectively. The share of science degree holders, as opposed to overall degree holders, including those in cultural and social sciences, in the United States, is 22.4 percent, which shows that approximately one out of four degreed persons has a degree in science. This is a very high number compared to the 10.8 percent in Japan.

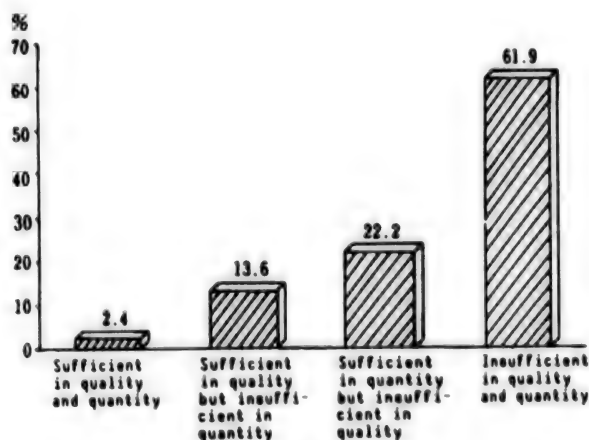


Figure 1-2-27. Transition of Number of Degree Holders in Leading Nations (Science, Engineering and Agricultural Fields)
Source: "International Comparison of Educational Indexes" by Ministry of Education

2) Securing and training creative researchers

While the number of researchers is growing steadily, "man-centered" R&D to bring out the originality of the individual researcher is becoming more important, accompanying the conventional "organization-centered" R&D, since the trend to strengthen original R&D, especially basic research, is gaining. Securing and training appropriate and diversified personnel are also demanded in the respective sectors.

(i) Future demands of researchers

According to the report of the Science Council (February 1984), the demand for researchers is estimated to total 596,000 by the year 2000, consisting of 389,000 for firms, etc., 50,000 for research institutes and 157,000 for universities.

However, in terms of researcher adequacy, there are a lack of researchers, both quality- and quantity-wise, in private enterprises as well even with their sharply increasing numbers of researchers, reflecting the recent trend to emphasize R&D. According to a survey of private trends, three of four firms replying to the survey claimed to lack quantity, and most firms indicated a shortage of talent in quality (Figure 1-2-28). This tendency is especially conspicuous in small businesses in which securing researchers is becoming a serious problem. In a survey of frontier S&T researchers, slightly more than 80 percent of the respondents felt a lack of researchers at the research site (includes those answering "lacking more or less"). Researchers belonging to national research institutes and private enterprises showed particularly high ratios, at 92 and 98 percent, respectively.

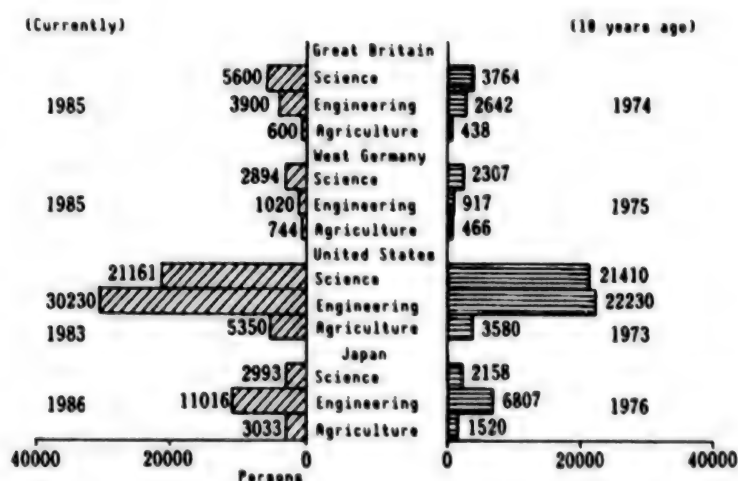


Figure 1-2-28. Adequacy of Researchers in Enterprises
Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

Considering the trends of business management toward technical priorities, the demand for researchers may even surpass the above estimate.

(ii) Securing research talent

In respect to the employment conditions at private enterprises, researchers with high academic backgrounds were remarkable. More than 50 percent of the researchers employed by larger enterprises, for example, have completed the master's degree program (Figure 1-2-29). Although a large share of the overall researchers are new graduates from universities, firms have started

to look for previously employed researchers (approximately 11 percent in 1985) in the past few years.

According to a survey of frontier S&T researchers, nearly half attached importance to scouting from other domestic organs in addition to recruiting examinations. Many also emphasized the employment of foreign researchers and foreign graduates (Figure 1-2-30). Consequently, there are indications that capable talent is being employed from various places beyond the conventional framework, with emphasis placed on the individual for creative basic research.

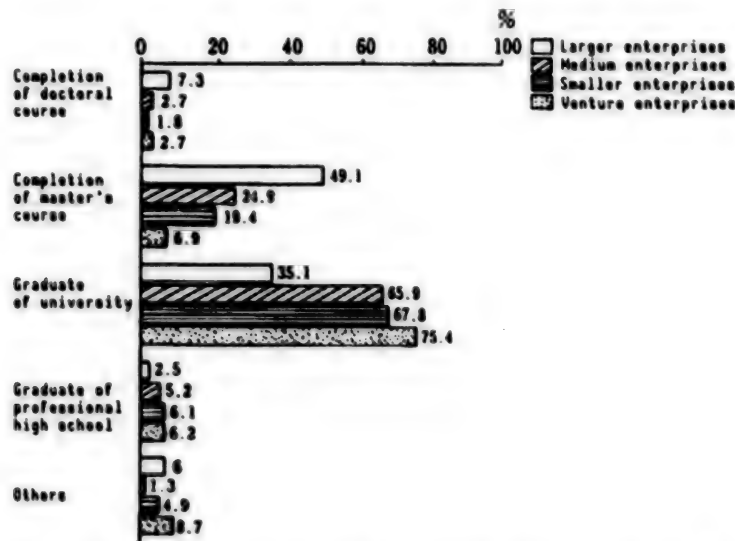


Figure 1-2-29. Qualifications of Research Personnel of Firms (1985)
 Source: Survey conducted through Special Coordination Funds for Promoting Science and Technology

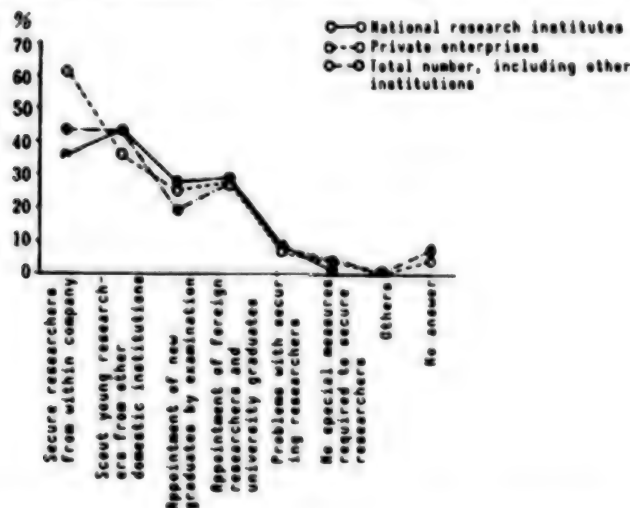


Figure 1-2-30. Methods of Securing Personnel for Creative Basic Research
 Source: "Survey on Frontier S&T Researchers"

The recent trend among the younger generation, including university students of science and engineering, to move away from the manufacturing industry has been pointed out. However, since basic research is beginning to be fully promoted, securing researchers with superior abilities is anticipated. In order to realize this, it is necessary that improved treatment and an attractive research site be provided.

(iii) Training of researcher

A great deal is expected of universities in training researchers. As already mentioned, degree holders, who are the main research participants, are steadily increasing to meet the needs of industrial circles. In 1985, the Japan Society for the Promotion of Science established the "Special Researchers System," a full fellowship program intended for cultivating the young creative researchers who are responsible for Japan's scientific research. Due to the extremely high expectations placed on this program, the system has been expanding each year.

According to a survey of trends in private businesses, the major measures used by enterprises to cultivate young research talent were to "increase opportunities to attend domestic and overseas academic meetings, etc." (52 percent), followed through "dispatching to outside research institutes (mainly domestic universities)" (49 percent) and "development and application of intra-firm and external training system" (41 percent). Most firms are trying to advance the quality of researchers in some form in order to cope with the rapid S&T advancement. Since merely 8 percent of all firms did not take any special measures, the industries' positive attitude toward the training of researchers is noticeable (Figure 1-2-31).

However, systems are also in place to advance the quality of researchers at national research institutes such as by dispatching them abroad or allowing them to study at domestic universities, or by dispatching personnel and making full use of the Law To Promote Research Exchange. The demand for improved researchers is extremely high with national research institutes are expected to activate their research activities.

(3) Receiving foreign researchers

The R&D sector of major powers have received foreigners extensively in the past, mainly in their public research institutes. In Japan, the tendency is also to accept foreign researchers from the standpoint of strengthening basic research and promoting international research cooperation in this age of technical globalization. Requests by other nations to Japanese institutes, including private firms, to receive researchers have also been made. Under these circumstances, visiting foreign researchers in various fields conducting R&D have increased in Japan. Due to the "Law To Promote Research Exchange" enacted in November 1986, it has become possible to employ foreign researchers in national laboratories. Although they are still few in number, three foreign researchers had been appointed to posts, as of October 1988. In FY 1987, approximately 80 researchers were accepted for stays of longer than half a year.

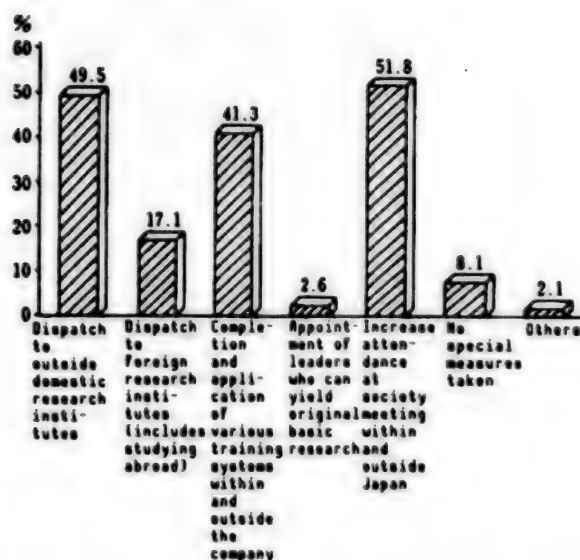


Figure 1-2-31. Measures To Advance Quality of Researchers of Enterprises

Note: Multiple answers applied.

Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

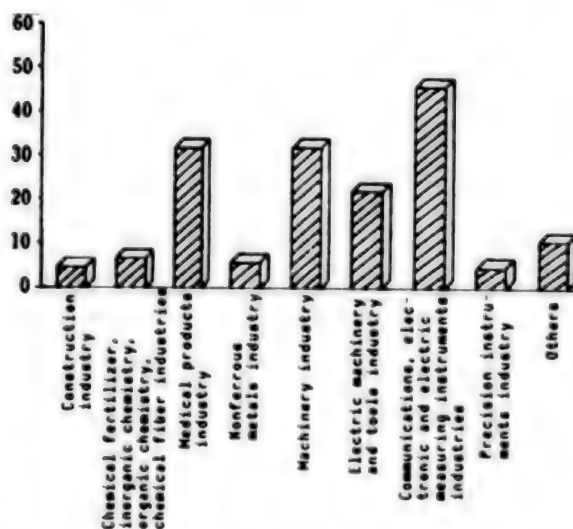


Figure 1-2-32. Appointment of Foreign Research Personnel by Private Enterprises

Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

There is also a growing tendency in the private sector to receive foreign researchers. According to a survey of trends in private enterprise, approximately 170 foreign researchers were reported to be employed in the firms which answered the survey. Many of the employers were from the high

technology fields which include the communications, electronics and electric measuring instrument industries, medical supplies industry and machinery industry. These industries have experienced remarkable technical progress and have participated in much technical exchange overseas (Figure 1-2-32). As for the size of the private firms concerned, the relatively larger enterprises were noticeable.

According to a survey of frontier S&T researchers, more than 50 percent of the researchers held a positive attitude about accepting foreigners as research personnel. They accounted for 58 percent in national research institutes and 48 percent in private firms (Figure 1-2-33) as well as 58 percent in the information and electronics field, 56 percent in the matter and materials field and 51 percent in the life sciences field. Consequently, visiting foreign researchers are expected to increase further, accompanying the promotion of research and researcher exchange.

As supportive measures, it is necessary that the living environment of visiting researchers be improved, language training facilities and agent service be provided, and cultural facilities be established for foreigners. Efforts to enable researchers of other nations to better understand Japan are also anticipated.

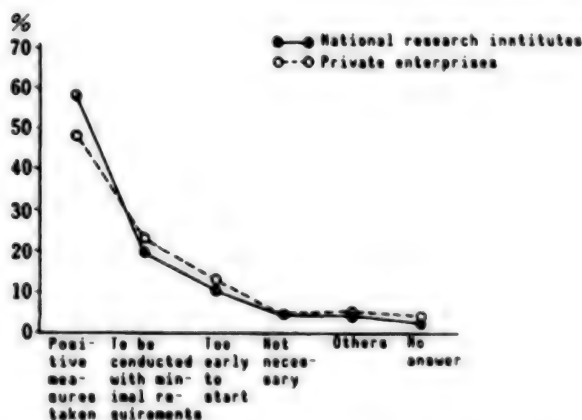


Figure 1-2-33. Appointment of Foreign Researchers
Source: "Survey on Frontier S&T Researchers"

4) Current conditions of research support personnel

Research support personnel, such as research assistants and technicians, are becoming increasingly important in promoting advance R&D measures and methods and efficiency in complex R&D, as well as from the standpoint of research operation that encourages researchers to concentrate on their research. However, the increase in the number of technicians, for example, was less than half that of researchers between 1982 and 1987.

More than 60 percent of the respondents to a survey of frontier S&T researchers also claim to lack technicians (Figure 1-2-34).

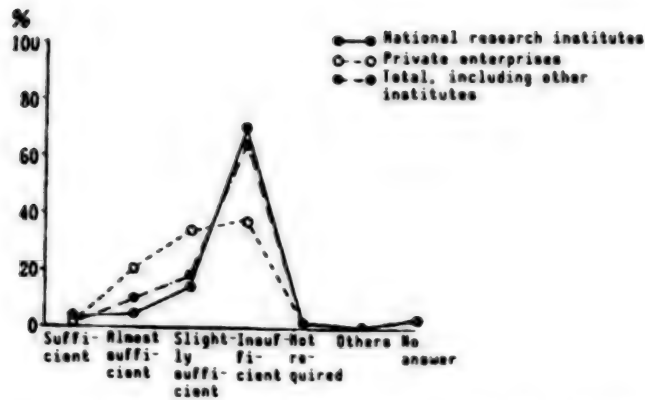


Figure 1-2-34. Sufficiency Situation of Technicians
Source: "Survey of Frontier S&T Researchers"

When this research support personnel (technicians) is compared internationally, the number of technicians per researcher (data from 1983) is 0.34 in Japan, which is one-fifth of that of France, one-third that of West Germany and approximately half that of Great Britain. The research support personnel in Japan, therefore, is relatively low.

An appropriate countermeasure for the lack of this personnel is demanded in future research operations.

The research personnel in Japan has been shown to have made considerable progress in quantity, mainly in the industrial circles. However, in order to develop sophisticated R&D, basic research and S&T activities, taking international harmony into consideration, it is necessary that highly creative research talent be secured, more foreign researchers be received and research support personnel be furnished.

2. Improvement of R&D Facilities and Equipment

As the scale of R&D enlarges and the boundaries and composite spheres of individual fields advance, research facilities and equipment become increasingly important. The conditions of these facilities and equipment, including their sophistication and standards, have been analyzed.

(1) Role and Rising Importance of Facilities and Equipment

(Tendency to aim toward a micro R&D)

The tendency of the present S&T research and development, mainly that of basic research, is to deepen and elaborate the existing S&T while returning to the basic principles and developments to conduct investigations and explanations. Sophisticated and efficient facilities and equipment are becoming the key to such R&D.

For example, unconventional approaches which unite methods of multiple fields, such as the analysis of the electronic state or crystalline structure of materials in the matter/material field or the structural and functional

analysis of nucleic acid or various proteins in the life science field, and sophisticated technology which realizes atomic and molecular level observations are becoming increasingly necessary. Measuring and analytical techniques using sophisticated facilities and equipment, such as synchrotron orbital radiation facilities (SOR), scanning tunnel microscopes (STM) and nuclear magnetic resonators (NMR), are also being assigned much greater roles (Table 1-2-35).

Table 1-2-35. Examples of Recent Research Facilities and Equipment
Exerting Great Impact on the Promotion of Basic Research

Item	SOR facility	STM	NMR (especially superconductive NMR)
Period	Radiation discovered in 1940s	1979	Principle discovered in 1940s
Principle	Intense light with wide wavelength, from extreme infrared to X-ray, applied to analyze material structure, etc.	Tunnel current between specimen and metallic needle measured to analyze surface structure	Existence of atomic nucleus analyzed, using nuclear resonance phenomenon
Main functions	Analysis of material structure, electronic state, etc., due to radioactive diffraction, diffusion, absorption, etc. Advanced time resolved analysis Highly refined processing	Analysis of material surface structure at atomic level, not only in vacuum but also in gas or liquid	Nondestructive analysis of materials Analysis of configuration and interaction between molecules of protein, etc.
Applications	Multiple fields, such as material science, electronics, biology, medicine, etc.	Multiple fields, such as material science fields, physics, biology, etc.	Multiple fields, such as chemistry, biology, medicine, material science, etc.

Source: Science and Technology Agency

The software technology of sophisticated processing analysis will also become necessary in order to promptly process, analyze and recognize the mass data measured and analyzed by sophisticated technology. Accordingly, sophisticated technology has started to play a great role in the excavation of new scientific intelligence in basic research. The advanced nations are competitively establishing and installing such sophisticated technology and related facilities and equipment, which are subjects of R&D themselves as well as indexes for the research standard of each specific field.

On the other hand, the researchers' efforts to combine research and device manufacturing, that is, for individual researchers to manufacture their own original devices to be used in their own research, is becoming markedly important, due to the necessity for advancing creativity and increasing detailed research.

(Rising dependency on R&D facilities and equipment)

Research expenses consist of salaries and wages, raw material expenses, tangible fixed assets (real estate, building, machinery, equipment, devices, etc.), purchase-related expenses and others. The share of expenses for machinery, equipment, devices, etc., in private enterprises has increased in almost every field during the past 10 years ago (Figures 1-2-36). This tendency is especially conspicuous in industries which depend largely on sophisticated technology, such as ceramics, nonferrous metals, the chemical industry, communications and electronics, and electricity and machinery. The ratio of the ceramic industry increased considerably, from 9.7 percent to 17.6 percent.

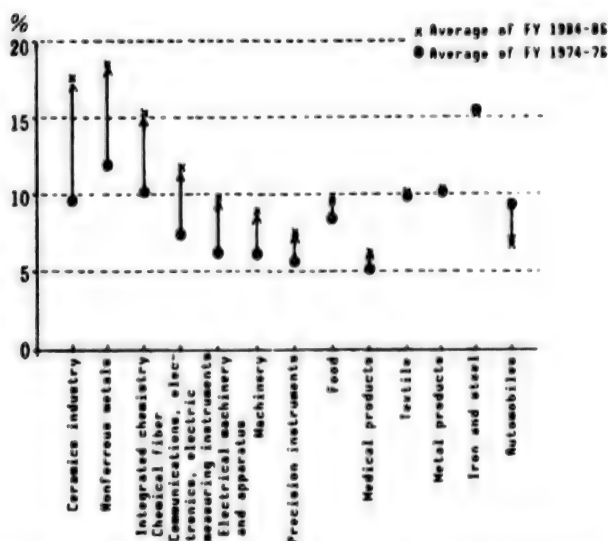


Figure 1-2-36. Ratio of Machinery, Equipment, and Device Expenses to Research Expenses

Source: "Investigative Report on S&T Research" by the Statistics Bureau of General Affairs Agency

According to a survey of private trends, the number of companies replying that dependence on facilities and equipment, especially in promoting basic research, will be "extremely high" or "high" amounted to 77 percent. This shows that the degree of dependence on research facilities and equipment in promoting basic research is rising, even in private enterprises (Figure 1-2-37). This tendency is particularly evident and recognized in larger enterprises and in industries involved in medical products and nonferrous metals.



Figure 1-2-37. Degree of Dependence on Research Facilities and Equipment

Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

Moreover, according to the "Academic Research Trends in Japan" submitted by the Scientific Council of Japan in April 1988, more than 70 percent of those in the engineering and science sectors and approximately 60 percent of those in the agricultural sector responded that dependence on experimental devices, observation and measuring devices, search and analytical measures, and larger computers is extremely high in research activities. Since there is a close correlation between the research standards and technical conditions, and greater dependence is placed on technical conditions in research with higher international standards, it can be said that the attainment of technical conditions is extremely important for the advancement of research standards.

(Recognition for completion of R&D facilities and equipment)

Accordingly, greater weight is attached to facilities and equipment in R&D, the same as for basic research. As a result of surveying frontier S&T researchers on the conditions of the existing R&D facilities and equipment, 77 percent of the respondents from private enterprises and 59.9 percent, those from national research institutes replied "sufficient" or "not sufficient, but manageable." While this indicates that the sufficiency is relatively high, the ratio of respondents who replied, "lacking" or "extremely lacking" were 20.6 percent and 37.1 percent, respectively (Figure 1-2-38).

Consequently, general purpose facilities and equipment have reached a level of sufficiency in private firms to a certain degree, mainly in the larger enterprises, although a slight shortage exists in other areas. The necessity to strengthen basic research must also be considered.

(2) Conditions of facilities and equipment in Japan

The standards of Japan's research facilities and equipment as well as those of its supporting functions, have been compared with those of the United States and Europe.

Researchers of frontier S&T fields, such as life sciences, matter/materials sciences, information/electronics sciences, and ocean/earth sciences, consider Japan's larger facilities to be considerably behind those of the United States, but on an equal level with those in Europe. Categorized by

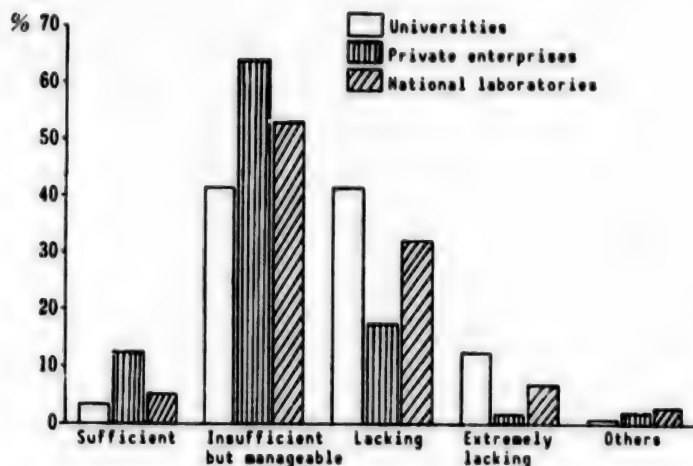


Figure 1-2-38. Sufficiency of Facilities and Equipment
Source: "Survey of Frontier S&T Researchers"

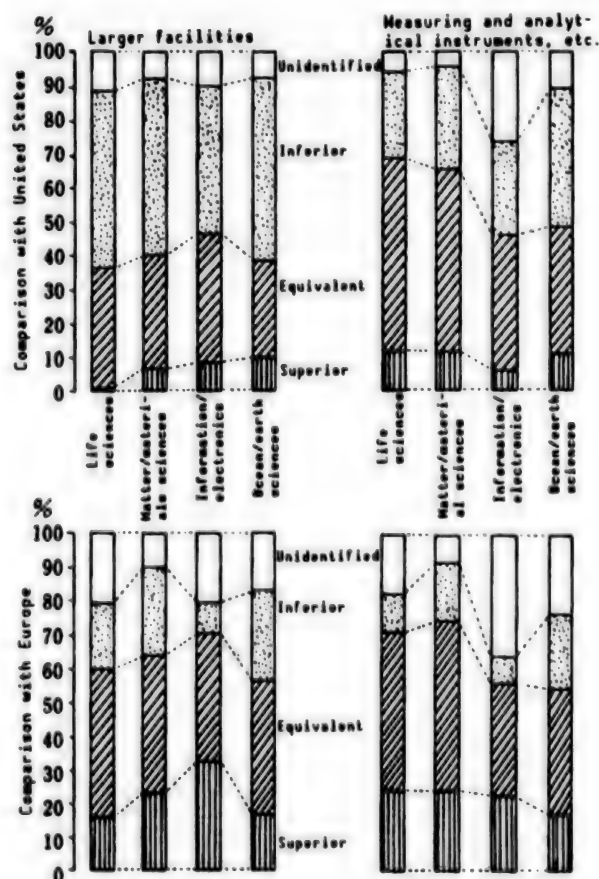


Figure 1-2-39. Standards of Research Facilities and Equipment in Japan
Source: "Survey on Frontier S&T Researchers"

institutions, researchers at national research institutes are more limited than those in the private sector. In the case of measuring and analytical equipment, etc., Japan is considered to be on equal terms, or slightly behind the United States, while being superior to Europe (Figure 1-2-39).

In order to compare the standards of Japan's R&D facilities and equipment with those of Western nations, typical facilities and equipment of the respective R&D fields, mainly of the basic and frontier S&T fields noted in the S&T Policy Outline, are listed in detail and their conditions and standards have been analyzed.

1) Larger facilities and equipment

(Accelerator)

The accelerator has made remarkable progress in the promotion of studies of the atomic nucleus and elementary particles. However, it has started to be used not only in research involving the nucleus and elementary particles, but also in such varying fields as chemistry, biology, engineering, medical science, etc.

Although there are many types of accelerators, cyclotrons and impact accelerators (colliders) are compared in Tables 1-2-40 and 1-2-41 as an index. A list of the relatively smaller cyclotrons, such as those for medical usage, is difficult to compile since there are many different ones in each nation. However, the number of facilities indicated in Table 1-2-40 indicates the overall conditions existing in each nation.

Table 1-2-40. Comparison of Number of Accelerators by Nation (Cyclotron)

Country	No of facilities	Country	No of facilities
Japan	16	France	6
United States	39	Great Britain	7
West Germany	11		

Source: Produced from "List of Cyclotrons," international conference data concerning the cyclotron and its application.

In terms of number of facilities, the United States is the best equipped nation, followed by Europe, which has a tradition of emphasizing basic science. Japan, which has been equipping facilities to catch up with the Western nations, has developed "Tristan," an electron/positron impact accelerator at the High Energy Physics Research Institute of the Ministry of Education, to conduct experiments and studies ranking in the top level internationally. Tristan, which was used successfully in an impact experiment involving 60 billion electron volts of impact energy in November 1988, is reestablishing the world's top energy record in an electron/positron beam collision ring. In Europe, the Commission Europeenne pour la Recherche Nucleaire (CERN) is presently constructing the LEP, the same type of

accelerator as Tristan, but with a greater energy capacity. It expects to start testing in 1989.

Table 1-2-41. Major Impact Accelerators by Nation

Japan	United States	Europe
Tristan, 30 GeV, 1986, High Energy Physics Research Institute	CESR, CHESS (also applied for radiation), 8 GeV, 1980, Cornell University	DCI (also applied for radiation) 1.8 GeV,
	PEP (also applied for radiation), 15 GeV, 1980, SPEAR (also applied for radiation), 4.5 GeV, 1972, Linear collider, 50 GeV, 1987 (under assignment), Stanford University	DORIS (also applied for radiation) 5.5 GeV, 1974 PETRA, 23 GeV, 1979, HERA (electron-proton), 30 GeV, (under construction), DESY (West Germany)
	Tevatron, 800 GeV, 1986, (proton-antiproton), Fermi National Institute of Accelerators	ISR, 28 GeV, 1971, SPS (proton-antiproton), 400 GeV, 1982, LEP, 50 GeV (under construction), CERN
		ADONE (also applied for radiation), 1.5 GeV, 1978, Frascati Research Institute (Italy)

- Notes: 1. Unit (GeV) of 1 billion electron volts applied. The same unit will be applied for diagrams and tables hereafter.
2. DESY is the abbreviation of Deutsche Electronic Synchrotron Research Institute, and CERN stands for Commission Europeenne pour la Recherche Nucleaire. These abbreviations will be used in figures and tables hereafter.
3. If not specified, colliders refers to lepton colliders with electron and positron accelerating particles. DESY's HERA uses the accelerating energy of electrons.

Source: Produced by the Science and Technology Agency from the Annual Report (1986) of the U.S. Department of Energy, etc.

(Synchrotron orbital radiation facility)

Synchrotron orbital radiation (SOR) refers to an intense light (electromagnetic wave) emitted when an electron accelerated close to the speed of light bends at the magnetic field. This radiation, which has a strong directivity and a continuous wavelength from the infrared/visible zone to the X-ray zone, is extremely effective in the analysis of materials, etc. It is also expected to be widely applied in various fields, including basic

Table 1-2-42. Major Radiation Facilities by Nation

Japan	United States	Europe
High Energy Physics Research Institute: PF 2.5 GeV 1982 ARE 6-8 GeV (planned) (common usage)	University of Wisconsin: TANTALUS: 0.24 GeV 1969 ALADDIN: 1.0 GeV 1985 Brook Haven Research Institute: NSLS-X: 2.5 GeV 1985 NSLS-OV: 0.7 GeV 1981 NBS (Surf-II) 0.24 GeV 1975	Dalsbery Nuclear Research Institute (Britain): 2 GeV 1980 Alcee Nuclear Research Institute (France): Super ACO 0.8 GeV 1988 DCI 1.8 GeV 1975 BESSY (West Germany): 0.8 GeV (1982)
Electronic Technology Research Institute: TERAS: 0.8 GeV 1981 NIJI: 0.27 GeV 1986		
Molecular Science Research Institute: UV-SOR: 0.6 GeV 1984	Stanford University: SPEAR: 4.5 GeV (common usage)	DESY (West Germany): DORIS 5.5 GeV (common usage)
Institute for Solid- State Physics: NTT: 0.4 GeV 1975 0.6 GeV 1988	Cornell University: CHESS-CESR 8 GeV (common usage)	Frascati Research Institute (Italy): ADONE (common usage)
	Argonne Research Institute: APS 6-7 GeV (planned)	ESRF: 6 GeV (planned)

- Notes: 1. The High Energy Physics Research Institute is under the Ministry of International Trade and Industry, the Molecular Science Research Institute is part of Okazaki National Organ for Joint Research of the Ministry of Education, and the Institute for Solid-State Physics is within Tokyo University. NBS is the National Bureau of Standards (reorganized in 1988) and BESSY is the Berlin Electronic Synchrotron Research Institute.
2. (Common usage) in the table represents facilities which are used in common for radiation and elementary particles, etc.

Source: Surveyed in Science and Technology Agency

research in life sciences, matter/materials sciences, etc. The synchrotron orbital radiation facility is used to conduct studies employing this extremely strong light. The major synchrotron orbital radiation facilities in Japan and overseas are shown in Table 1-2-42. With 2.5 billion electron volts (2.5 GeV), the synchrotron orbital radiation experimental facility at the High Energy Physics Research Institute of Japan's Ministry of Education meets the top class of international standards. Plans are already being made for six GeV class large-scale synchrotron orbital radiation facility to be established in the United States and Europe. The Advanced Photon Source (APS), with 6-7 GeV, is scheduled for completion in 1992 at Argonne National Research Institute by the U.S. Energy Department. In Europe, the 6 GeV European Synchrotron Radiation Facility (ESRF) is expected to be completed

in Grenoble, France by 1991 by the EC (France, West Germany, Great Britain, Italy, Spain, etc.). In Japan, a high intensity X-ray-emitted light source facility using storage rings in Tristan (6-8 GeV) is underway at the High Energy Physics Research Institute, and a new large-scale synchrotron orbital radiation facility is also being researched through the cooperative efforts of the Institute of Physical and Chemical Research and the Japan Atomic Energy Research Institute.

(Ultrahigh magnetic generator for superconductive material research)

Superconductivity is a phenomenon in which the electric resistance becomes zero under a certain temperature. Its application fields extend widely, and include energy, medical science, transportation, electronics, etc. The successive discoveries of new superconductive oxide materials in 1987 raised the expectations for its possible applications and created a great international sensation due to the new technological innovations it brought.

While each nation has been engaged in remarkable R&D since its discovery, the research of new superconductive materials has only just started, and it is still important to promote basic research. Superconductivity, which has a close and inseparable connection with magnetic fields, cannot break its state when a large magnetic field is applied. Developing a material capable of running a large electric current is also a great issue when putting superconductive material into practical use. The facilities and equipment for generating a super-strength magnetic field, capable of the multiple analyses of magnetic fields, currents, outer pressures, etc., are required in order to promote the R&D of superconductive materials. Looking at the plans and conditions for each nation's super-strength magnetic field generating facilities and equipment, Japan can be seen as leading the world, similarly to the position it holds in research standards (Table 1-2-43).

(Supercomputer)

Although its definition is not quite clear, a scientific and technological processor with more than 10 times the capacity of a general computer is called a supercomputer. Supercomputers capable of S&T computing at a superspeed are applied in various fields, such as aircraft design, space development, the forecasting and research of meteorological conditions, the R&D of nuclear fusion, etc. Its fields of application have been expanded to include molecular chemistry, astronomy, life sciences and matter/material engineering, and it is becoming a requisite in the latest S&T fields.

According to a survey by the National Science Foundation (SNF) of the United States, in 1986 approximately 120 supercomputers were installed in the United States and 50 in Japan. Classified by organ, approximately 70 and 20 supercomputers were installed in the United States and Japan, respectively, in universities and governmental research organs. However, there has recently been a conspicuous increase in installations in Japan (Table 1-2-44).

In the United States, the NSF and others are promoting the development and diffusion of supercomputer applied technology. Supercomputers are connected by circuits to construct a supercomputer network to be available to many organs.

Table 1-2-43. Japan, United States and European Superstrength Magnetic Field Generating Facilities and Equipment

Facilities, equipment	Japan	United States	Europe
Superstrength critical magnetic field	50T-class 2 millisecond (Tohoku Univ.)	50T-class 10 millisecond (MIT)	40T-class 10 millisecond (Amsterdam U., Netherlands)
Long-pulse magnet and pulse magnet	80T-class NRIM (National Research Institute of Metals-- under construction)	60T-class 3 millisecond (MIT)	
Superstrength magnetic	31T-class (Tohoku Univ.)	31T-class (MIT)	30T-class (Neijmegen U., Netherlands)
Current density	40T-class NRIM (Tohoku Univ.)		31T-class (Grenoble, France)
Hybrid magnet			20T-class (Oxford U. England)
Stabilization			
Large aperture super-conductive magnet	12T-class (360 aperture (Tohoku Univ.) 11T-class (200 aperture (Atomic Energy Research Institute) 14T-class (180 aperture) NRIM 11T-class (200 aperture) Kyushu U.) 20T-class (150 aperture) NRIM (under construction)	12T-class (300 aperture) (Lawrence Liver- more National Laboratory) 13T-class (420 aperture) (MIT)	16T-class (150 aperture) Karlsruhe Kernforschung szentrum 11T-class (360 aperture) (Neijmegen U., Netherlands) 19T-class (70 aperture) (LASA, Italy)

Notes: 1. MIT: Massachusetts Institute of Technology

2. T: tesla

Source: Surveyed by Science and Technology Agency

Table 1-2-44. Number of Computers Installed in Japan and United States

Country	1983		1984		1985		1986	
	Japan	U.S.	Japan	U.S.	Japan	U.S.	Japan	U.S.
Governmental research institutes	(2)	23	(4)	26	(9)	39	(19)	57
Universities		3		5		14		14
Private industries	3	20	9	22	17	46	33	50

Source: Prepared from NSB Science Engineering Indicators 1987

(Larger wind tunnels)

Larger wind tunnels are indispensable in the research involving aerodynamics, such as in estimating the performances of aircraft, rockets, etc. It also has great advantages, since it is easy to set up testing conditions and is capable of high precision measuring. Particularly, in order to cope with the coming space age in which space stations will be utilized, high performance, larger wind tunnels are becoming important in promoting the R&D of a safer, easier, and innovative space traffic system. Observing the number of wind tunnel facilities of the various nations, the superiority of the United States, which has been accumulating experience in the aviation and space fields the longest, becomes conspicuous as the wind speed increases (Table 1-2-45).

(Astronomical observation facility)

Observations in space science and astronomy are currently conducted using electromagnetic waves of most wavelengths, from gamma rays, with extremely short wavelengths, and X-rays to electric waves with long wavelengths. Observations are also made by nonelectromagnetic waves, such as neutrino and gravitational waves. Electromagnetic waves which fully reach the ground surface are in the optical infrared area and the electric wave area. Due to the advancement of infrared astronomy, along with the development of semiconductor technology in the 1960s and the advent of the semiconductor image detector in the optical infrared area in the 1980s, ground observation technology has made rapid progress.

The advancement in observation technology has also enriched the contents of astronomy, which is supported by the development of observation devices, due to larger telescopes, higher precision, mass data processing, etc., and the advancement of observation measures outside the atmosphere resulting from improved space technology, such as artificial satellites.

Table 1-2-45. Comparison of Larger Wind Tunnels by Various Countries

Country Classification	Japan	U.S.	West Germany	France	Great Britain
Subsonic wind tunnel					
A: over 25 m ² or B: over 5 x 10 ⁶	2 (2)	8 (5)	3 (2)	2 (2)	3 (3)
Transonic wind tunnel					
A: over 2 m ² or B: over 1 x 10 ⁷	1 (1)	14 (9)	0	2 (2)	3 (3)
Supersonic wind tunnel					
A: over 1 m ²	1 (1)	16 (9)	0	1 (1)	3 (3)
Hypersonic wind tunnel					
A: Diameter over 50 cm	1 (1)	24 (19)	1 (1)	2 (2)	1 (1)

Note: (): Number of government institutes

* : Includes joint R&D of West Germany, France and the Netherlands

A: Cross sectional area; B: Reynolds number

Source: Prepared from NASA "Aeronautical Facilities Catalogue (Vol 1), Wind Tunnels" 1985, etc.

Table 1-2-46. Major Optical Telescopes by Nations (over 300 cm aperture)

Aperture	United States	Europe	Soviet Union
Over 400 cm	Paloma (1948) Mt. Hopkins (1978) Cellotorolo (1974)	La Paloma (1987)	Zerenschusukaya (1976)
300-400 cm	National Kitt Peak (1973) Mauna Care (1979) Mt. Hamilton (1959)	Saiding Springs (1974) Mauna Care (1979) La Sha (1976) Mauna Care (1980) La Sha (1988)	

Notes: 1. Year in () is period of construction.

2. The largest optical telescope in Japan is in the astronomical observatory of the Ministry of Education, with an aperture of 188 cm (1960). There are more than 40 telescopes with apertures greater than 180 cm.

Source: Produced by the National Astronomical Observatory, Ministry of Education

While there are various types of ground observation facilities, the conditions of optical telescopes are listed in Table 1-2-46. The United States is followed by Europe in having superior facilities, while the Soviet Union also has large facilities. The United States also takes the lead in radio telescopes, having a wide range of devices in its four major facilities. Europe offers an observation facility for submillimeter waves, while in Japan, the National Cosmos Radio Emission Observatory in Nobeyama Astronomical Observatory leads the world in millimeter wave observation performance with its 45 m mirror, etc.

The United States also has a long history of achievements involving the use of artificial satellites, etc., in astronomical observation, beginning with Explorer 11 launched in 1961 which loaded a gamma ray space telescope. Satellites such as "Hakucho" (1979), "Tenma" (1983) and "Suisei" (1986) have been launched by Japan, mainly under the direction of the Space Science Research Institute of the Ministry of Education. Responding to the request for cooperation with the United States and Great Britain, Japan is conducting X-ray astronomical observations using the scientific satellite "Ginga" (1987), which loads each nation's observation equipment.

(Oceanographic vessels, bathyvessels)

The ocean, which exerts a great influence on meteorological changes due to its interaction with the atmospheric circulation, is directly as well as indirectly connected to the society and economy. Oceanographic vessels are an effective means of promoting marine development as well as explaining various phenomena of the earth due to oceanographic changes, thereby gaining a better overall understanding of the earth. Comparing the relatively larger oceanographic vessels (over 50 m total length) of the United States and Japan, Japan has approximately one-half the number held by the United States (Table 1-2-47).

Each nation is promoting the R&D of manned oceanographic submersibles, which is the major means of conducting deep-sea surveys. Comparing the number of vessels owned by each nation, according to the "Undersea Vehicles Directory 1987," the United States has 26 vessels, followed by 15 for Great Britain, 10 for France, 4 for West Germany (6 when including those under construction) and 4 for Japan (5 when including 1 under construction) (Table 1-2-48). The United States has far more vessels capable of deep-sea survey beyond 1,500 m than does any other nation.

Since Japan is also exerting efforts in this field, the Marine Science and Technology Center is currently constructing the "Shinkai 6500" (provisional name), which will be capable of surveying deeper than 6,000 m. Upon its completion, Japan will join France in ranking with the United States.

Table 1-2-47. Comparison of Oceanographic Research Vessels by United States and Japan

Year of construction	United States	Japan
Prior to 1959	1	1
1960-1964	9	2
1965-1969	20	8
1970-1974	10	6
1975-1979	6	8
1980-	4	5
Unknown	1	-
Total	51	30

Notes: 1. Oceanographic research vessels are limited only to those over 50 m length.
 2. For comparison, vessels owned by education institutes are limited to those of the universities and higher education institutes.

Source: United States: Prepared from Research Vessels, Sea Technology Buyers Guide Directory
 Japan: Prepared from the National Oceanographic Research Vessels, Maritime Safety Agencies

2) Facilities to supply genetic resources, experimental materials, etc.

(Facilities to collect, store and supply genetic resources)

Since organisms such as plants, microorganisms, cultured cells, etc., form the base in promoting life science research, facilities and activities to systematically collect, conserve and supply these materials are extremely important.

The Western nations, which have a long history of preserving microorganisms, in particular, for museums, have expanded their usages to include diverse materials. The number of organs which conduct such activities for microorganisms, cultured cells, etc., for each nation is listed in Table 1-2-49. Among the individual organs, the ATCC (American Type Culture Collection) in the United States takes pride in its long history, abundant conservation and amount of supply (Table 1-2-50 [not reproduced]).

According to a survey by the Ministry of Agriculture, Forestry and Fisheries, the number of plant genes, such as seeds, etc., currently being preserved in Japan is approximately 130,000, while approximately 340,000 are preserved in the United States.

In addition to the individual organisms, isolated genes, as well as separated and cultured animal and plant cells, have become widely applied as research material. The demand for them is rising along with the increased research activities in the life sciences. The United States has taken an overwhelming lead in this field as well, mainly through the efforts of the ATCC.

Table 1-2-48. Comparison of Manned Oceanographic Submersibles of Nations by Depth

Depth	Japan	United States	West Germany	France	Great Britain
Under 300 m class	OHakuyo OPC1205	OOOOO OOOOO OO	OOAA	OOOO	OOOOO O
400-600 m class		OO	OO	OOOO	OOO
700-1,000 m class		OOOO			OOOOO O
1,500 m class		OAvalone OMistic			
2,000 m class	OShinkai 2000	ODeep Quest OPisces V OPisces VI OTurtle		OShiana	
4,000 m class		OAlbin			
6,000 m class	OShinkai 6500	OSea Cliff		ONotile	
Unidentified	O				
Totals	4 (5)	26	4 (6)	10	15

Notes: 1. Among the types of submersibles, only "Antezard" and "Rockout Vehicle" were classified.

2. A indicates under construction.

Source: Produced from "Undersea Vehicles Directory 1987" by Busby Associates Inc.

Table 1-2-49. Number of Organs Preserving and Supplying Cultured Organisms by Nations

Nation	Japan	United States	West Germany	France	Great Britain
Number of organs	12	28	12	11	30

Source: Produced from "World Directory of Collections of Cultures of Microorganisms," Third Edition, 1986, by World Data Center

In Japan, efforts have been made to complete the collection, conservation and supply demands of genetic resources, such as microorganisms and plants. Concerned ministries and agencies are initiating and strengthening various undertakings to meet the rapidly rising needs in this field.

(Facilities for development, production and supply of experimental animals)

Since experimental animals are requisites in the research of life science fields for use as models to disclose the functions of living bodies and human diseases, animals ranging from smaller ones, such as mice, rats, etc., to larger ones, including cows and pigs, and from larger primates such as monkeys to invertebrates including drosophilae are used. The development, production and supply of quality-controlled animals with clarified genetic lineage, infections, etc., are required in order for these experimental animals to be used.

The production and supply of smaller animals, such as mice, rats, etc., have also been conducted in Japan by the private sector. The government and private businesses have also been developing gene transduced animals and establishing new experimental animals closer to primates, although the systems to preserve and supply newly developed animals are not currently well established.

There is little quality control of larger primates, especially of wild kinds, which are needed because of their close biological proximity to man for research on the highly sophisticated functions, such as those of the brain and nervous system and study of the effects of vaccines. Because some of those animals are under the protection of the "International Transaction Agreement Concerning Wild Animal Species in Danger of Extinction," popularly known as the "Washington Agreement," it is necessary to supply them by breeding them domestically.

The necessity of self-propagation facilities was recognized early on in Western nations. In the United States, the "National Primate Plan" was founded in 1978 and the National Institutes of Health (NIH) currently has seven primate centers nationwide which produce and supply experimental primates for joint or consigned research involving AIDS, etc. Although self-propagation is also conducted in Japan by some organizations, its application is limited to within the organization. In terms of the supply system, Japan is behind other major nations (Table 1-2-51).

(Facilities to supply reference material)

Reference materials which are required to conduct analysis, measurement, identification, etc., are necessary for the assessment and confirmation of test results. Therefore, establishing an appropriate supply system is important in promoting the R&D of mainly frontier S&T, such as matter/materials or life sciences.

The Western nations, especially the United States, have an established supply system, mainly in public organs. In case of the United States, a unified

Table 1-2-51. Number of Experimental Primates Produced

Nation	United States	West Germany	France	Great Britain	Japan			
Year	1980	1981	1981	1981	1981	1981	1980	
Type species					A	B	C	Firms
Rhesus monkey	6,024	191	4	38	—	21	33	—
Crab-eating monkey	—	95	88	68	351	—	—	—
Macaque (other than above species)	960	1	4	—	—	—	—	—
Baboon	113	2	25	—	—	—	—	—
Marmoset	—	242	49	727	—	44	—	—
Squirrel monkey	427	34	—	2	4	—	—	50
Green monkey	—	—	—	—	18	—	—	—
Japanese monkey	—	—	—	—	—	—	4	—
Others	711	108	—	17	—	—	—	—
Total	8,235	673	170	852	373	65	37	50

Notes: A: National Institutes of Health

B: Research Institute of Experimental Animals

C: Primate Research Center of Kyoto University

Source: Special Research Report of Experimental Primate Committee (Fiscal 1981)" by the Ministry of Health and Welfare

control and supply system of reference materials has been constructed, led by the National Bureau of Standards (reorganized to the National Association of Standards and Technology Research) in cooperation with other related organs. Over 900 standard reference materials (SRM) are sold as data.

In Japan, national organs and business groups (for example, the Iron and Steel Association in the case of iron and steel) of the respective fields requiring reference materials are independently manufacturing, confirming and distributing reference material, since no one organ can regulate the supply of reference materials and exert uniform control over information.

3) Overall assessment

Comparing the overall standards of research facilities and equipment, mainly by the facilities and equipment of the above-mentioned sectors, Japan can be said to have reached the stage ranking with Europe due to recent advancements in the latest facilities and equipment. However, a large gap with the United States remains, not only in size, but also in quality. Japan is particularly lacking in supportive functions, such as facilities for supplying experimental materials, etc.

The latest larger R&D facilities and equipment in Japan are being completed to meet the marked advancement of S&T standards. The possession and operation of internationally influential facilities and equipment are

expected from the standpoint of meeting sophisticated domestic needs and contributing to the world.

(3) Making national facilities available to private sector

Universities and governmental research organs play a great role in the pursuit of innovative technical seeds and creative and basic research. Since these organs also have important facilities and equipment, along with the above, function, it is necessary to establish major facilities and equipment and make them accessible for proper application.

According to a survey of private trends, most private businesses are using outside facilities and equipment for R&D. The most often used facilities and equipment were in universities (46 percent), followed by other domestic firms (32 percent), public laboratories (27 percent) and national laboratories (25 percent). Looking at the private businesses by size, many of the relatively smaller firms tend to use other domestic firms, while the number of firms using the facilities of national laboratories or universities increased with larger capital. Among the firms using national laboratory facilities and equipment, only 16 percent had capital of ¥1-5 billion, while approximately 40 percent of the firms with capital of over ¥10 billion used the facilities (Figure 1-2-52).

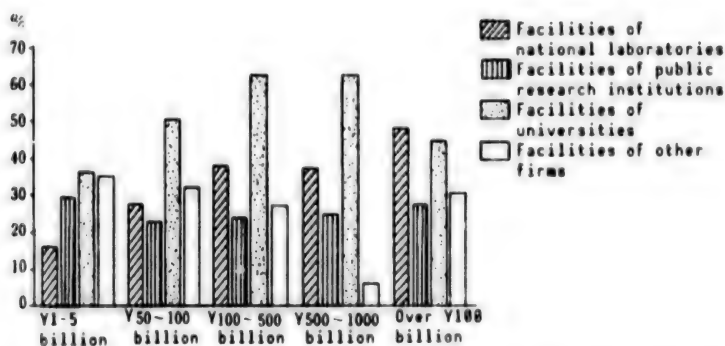


Figure 1-2-52 Outside Facilities and Equipment Used by Private Firms

Note: Multiple answers used.

Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

According to a survey of what the firms will do when larger and more expensive facilities and equipment become necessary in order for basic research to be conducted, 86 percent replied they would consider using outside facilities and equipment, while only 12 percent intended to equip facilities on their own. This trend is generally the same, regardless of the size of the firm.

Japan has been equipping the larger research facilities and equipment which cannot be duplicated by the private sector. The government has also been

among government research institutes, universities and private enterprises, technical guidance, etc. It has also become possible for private firms to use governmental facilities and equipment at a moderate cost following the enactment of the Law To Promote Research Exchange.

However, not a few problems have been raised concerning the use of such facilities and equipment of public organs. Many of them replied, "limited facilities are available for use, to begin with," (47 percent) and "procedures are too complicated" (44 percent) (Figure 1-2-53). The first problem concerns restrictions on researchers using the facilities, such as limiting use only to those engaged in joint research. While the use of research facilities and equipment by outsiders through joint research is increasing, this restriction of usage opportunities to other researchers should be studied. In order to increase the use of research facilities and equipment by outsiders, it is necessary to prepare the supply side, improve manpower, such as operators, maintenance and management personnel, and secure operation expenses.

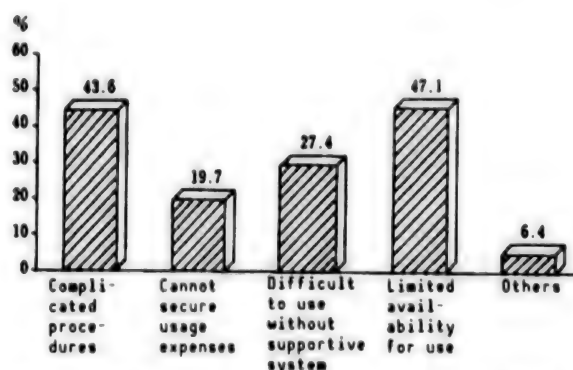


Figure 1-2-53. Problems With Making Research Facilities and Equipment Available

Note: Multiple answers supplied.

Source: "Survey of Frontier S&T Researchers"

As for sharing expenses among industries, universities and government organs, expenses sharing by proper beneficiaries, and the third sector operation by private investment, must also be considered. In October 1988, the new Energy Industrial Technology Development Organization began to equip larger research facilities, difficult for private firms to complete, for the common use of those engaged in domestic and overseas R&D involving industrial technology.

Although it is necessary to accept and employ researchers from abroad in the existing research facilities and equipment, it is also necessary to make facilities and equipment attractive to foreign researchers if we are going to make our research facilities and equipment available internationally.

For example, the attraction of the Japan Atomic Energy Research Institute, which receives many researchers from overseas, is largely due to its research facilities being on the top level in the world, starting with its JT-60.

(4) Renewal and improvement of facilities and equipment

1) Revision of facilities and equipment

(Trends of national laboratories and universities)

Ten years have passed since Tsukuba Science City gathered the key research organs of Japan. Its facilities and equipment are now pointed out as being too timeworn and trite for use in up-to-date research.

Consequently, a budget to renew and expand facilities and equipment was included in the supplementary budget (No 1) of FY 1987. A total of approximately ¥79.2 billion was added to the Expenses for Promotion of Science and Technology for facilities (Table 1-2-54). National laboratories, etc., therefore, have been able to plan full renewal of facilities and equipment in FY 1987. Further efforts to continue this plan are demanded (Figure 1-2-55).

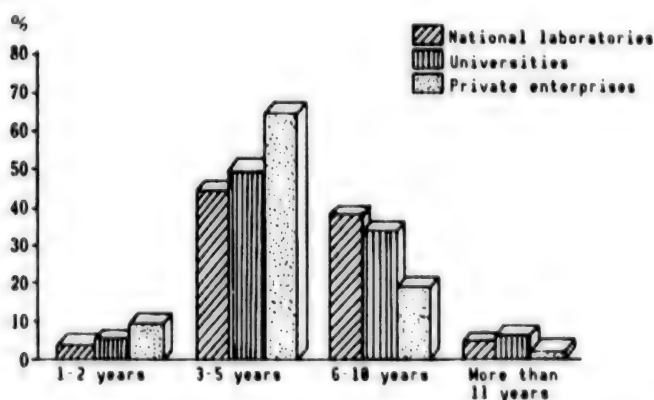


Figure 1-2-55. Number of Years of Research Facility and Equipment Usage
Source: "Survey of Frontier S&T Researchers"

Meanwhile, the Ministry of Education has been engaged in expanding international university institutes, improving research facilities, etc., in universities and strengthening subsidies for research facilities and devices of private universities as a part of the measures to assist private schools.

In respect to the above-mentioned R&D facilities and equipment, it was agreed at the OECD's Science and Technology Ministers Meeting that each nation should strengthen them in order to promote basic research and sharing the responsibility for it. In the United States, universities' research facilities and equipment, supporting the basic research which has been leading the world, have been aging rapidly. Consequently, the Department of Defense (DOD) started a new program in 1983 to purchase expensive R&D facilities and equipment. The National Science Foundation (SNF), the Department of Energy (DOE) and the National Institutes of Health (NIH) have also started similar plans. The 1988 Law concerning General Trade and Competition also encourages the "Research Facilities Modernization Plan" by

Table 1-2-54. Itemization of Expenses for Promotion of Science and Technology in FY 1987 Supplementary Budget (No 1)
(Unit: ¥1 million)

Ministries and agencies	Items	Additional budget
Diet	Purchase of S&T-related material	250
National Police Agency	Expenses for research center equipment	741
Hokkaido Development "	Expenses for laboratory equipment	97
Science and Technology Agency	Expenses for research institute facilities	20,937
Environment Agency	Expenses for research center facilities	2,092
Ministry of Finance	Expenses for brewing laboratory equipment	82
Ministry of Education	Expenses for research center facilities Expenses for observation of South Pole, etc.	1,649
Ministry of Health and Welfare	Expenses for research institute facilities	4,642
Ministry of Agriculture, Forestry and Fishery	Expenses for facilities and equipment, etc.	13,055
Ministry of International Trade and Industry	Expenses for facilities, purchase of very high speed computer, etc.	24,066
Ministry of Transport	Expenses for facilities and equipment, etc.	4,061
Ministry of Posts and Telecommunications	Expenses for facilities of Radio Research Institute, etc.	6,333
Ministry of Labor	Expenses for equipment	110
Ministry of Construction	Expenses for equipment	1,050
Ministry of Home Affairs	Expenses for equipment	59
Total		79,224

Source: Survey by Science and Technology Agency

the NSF. Similar to the United States, other major nations are also equipping the required R&D facilities and equipment in order to secure their basic research capacity.

(Trends of private enterprises)

In the recent R&D, high performance research facilities and equipment have also become increasingly necessary in private enterprises. From the results of surveying frontier S&T researchers regarding the cost of facilities and equipment which each research organ can afford, the largest number of private firms assign a standard of ¥50-100 million, although this may differ according to the research field, size of the research organ, research contents, importance of the research theme, etc. It can be said that private enterprises have extremely high standards in this respect, reflecting the intense competition and positive attitudes toward R&D in the recently emerging frontier S&T fields.

One aspect which supports the current high standards of Japan's industries is the introduction of the latest instruments for analysis and measurements. Even in the survey of private trends and survey of frontier S&T researchers, the installation of such instruments is thought to be at the highest level in the world. The domestic output of general use instruments for analysis, for example, shown in Figure 1-2-56, has been increasing due to the high demand from industrial circles.

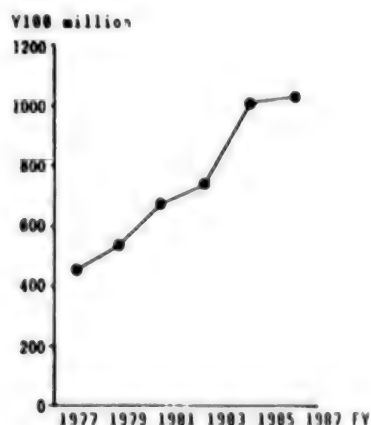


Figure 1-2-56. Domestic Output of Experimental Analyzing Instruments
Source: Data of Japan Analyzing Instruments Association

2) Improvement of facilities and equipment

The above-mentioned conditions and standards of Japan's R&D facilities and equipment have been progressing along with the recent increase in S&T activities. Private enterprise, mainly the larger ones, can also be said to have made considerable achievements in these standards.

Meanwhile, the R&D facilities and equipment of universities and national laboratories can also be deemed to have made considerable achievements in standards, mainly those in frontier R&D. Universities and governmental research institutes are expected to play an even greater role, as the recognition to strengthen basic research rises and basic and applied research progresses. It is indispensable that the facilities and equipment of these research institutes continue to be expanded when promoting frontier R&D so that new S&T seeds, which may later be applicable as new scientific information, can be born.

Based on the R&D trends, mainly those involving basic and frontier research which the government is particularly required to conduct, it is necessary to place priority on newly-developed facilities and equipment which may open up possibilities of future research, large facilities and equipment which are generally beyond the expectations of private businesses and various research support facilities, in addition to the already established research facilities and equipment. Since these facilities and equipment are, on the whole, expensive and scarce, they must be open to foreign researchers as well as to domestic organs. It is also necessary to give full attention to required measures regarding operational expenses, etc., to guarantee efficient operation, in which case burden sharing by beneficiaries will also be considered.

Japan is in a position to construct some international-level R&D centers with key facilities and equipment open to the world, where prominent Japanese researchers may gather, thereby acquiring a so-called Center of Excellence.

3. New Developments in S&T Information Activities

S&T information and its dissemination is becoming increasingly important, accompanying the sophistication and complication of S&T, the promotion of basic research and the strengthened competitiveness of the nations. In this section, the foundation for promoting information and its wide-ranging activities, including international cooperation, are discussed.

(1) Creation and distribution of results as basis for R&D activity

1) Importance of S&T information distribution

Information-related activities, such as obtaining information for R&D or announcing research outcomes, are becoming increasingly important. In an agreement reached at its October 1986 ministerial meeting, the OECD, which promotes cooperation between advanced nations, proposed an open system to officially announce the results of basic research in order to expand the accumulation of human knowledge through the internationalization of S&T. Taking the advice of the OECD's board of trustees, the "General Framework of Common Principles for International Cooperation in S&T" was set up in April 1988.

In consideration of the fact that each nation's economic growth and social development exceedingly depends on the progress of S&T knowledge brought

about through wide-ranging exchange of information among scientists, research institutes and nations, it has been recommended that basic research results be diffused through the presentation of internationally applicable scientific documents, data banks, access to networks and freely attended science-related meetings.

Meanwhile, it was also indicated by the Policy Committee of the Scientific and Technical Council at a conference on international issues that the promotion of free research exchange and the dissemination and disclosure of research results, etc., should, as a rule, be a primary principle of international relations.

Accordingly, the importance of S&T information and its free dissemination has been pointed in Japan as well as elsewhere in the world.

2) Presentation of research outcome

The outcome of research activities is considered to contribute to the advancement of academic fields generally through presentations, discussions between researchers, etc. Since basic research fields place priority particularly on the assessment of the outcome of presentations, 84 percent of the frontier S&T researchers were "positive toward presenting" the outcome of basic research (Figure 1-2-57).

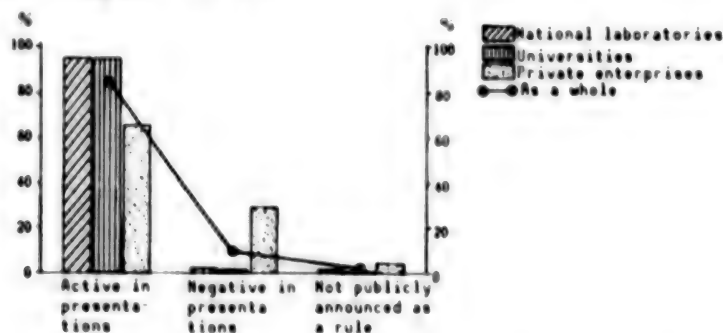


Figure 1-2-57. Presentation of Basic Research Outcome
Source: "Survey on Frontier S&T Researchers"

While more than 50 percent of the private enterprises with capital of over ¥50 billion were found to be positively and widely disclosing research outcomes as social contributions, less than 20 percent of the businesses with capital of under ¥5 billion showed a positive attitude.

3) Basic information distribution activities

Societies play an important role in the presentation of research results and exchange of information. Major overseas societies, such as the Material Research Society (MRS) of the United States, which has recently been very active, have become extremely popular sites for capable researchers from various nations to exchange and discuss information. They also serve as meeting places for industries, universities and governmental organs.

Similar trends are also appearing in domestic societies, mainly in boundary fields which are experiencing marked technical progress. The number of members of these societies are also increasing as the industrial circles strengthen basic research. They are also starting to handle important activities, such as interdisciplinary fields and internationalization (Table 1-2-58).

Table 1-2-58. Major Societies in Japan (FY 1987)

Title Note 1) (Societies)	No of members (persons)		No of theses annu- ally	No of Japanese journals published 2	No of English journals 2 published	
	Total	Foreign- ers			Total	Foreign- ers
Applied Physics	17,080	115	1,170	15,300	3,840	1,150
Electricity	23,949	—	369	24,800	500	400
Electronic Information/ Communications	34,803	140	912	43,200	1,600	380
Civil Engineering	28,220	273	246	3,900	500	200
Japan Chemistry	36,790	384	1,818	5,000	4,700	1,390
Japan Machinery	39,888	225	1,311	5,400	1,000	700
Japan Construction	29,401	118	291	8,900	0	0
Japan Biochemistry	12,000	100	374	11,000	2,650	1,430
Japan Agricultural Chemistry	12,379	290	617	5,800	3,450	1,068
Japan Physics	14,123	120	597	0	2,800	1,016

Notes: 1. In order of Japanese syllabary

2. Circulation per volume

Source: "Lists of Academic Research Groups in Japan" by Japan Academic Council

The theses contributed and printed in society journals, an important means of circulating research results, have increased considerably, including those printed in the English journals published in Japan.

Looking at the means of presenting research by frontier S&T researchers, the Western nations, which conduct 60 percent of the presentations in society journals and seminars, tend to emphasize presentation in comparison with Japan, where 33 percent of the presentations were in society journals and seminars. This tendency is especially notable in life science fields (Figure 1-2-59).

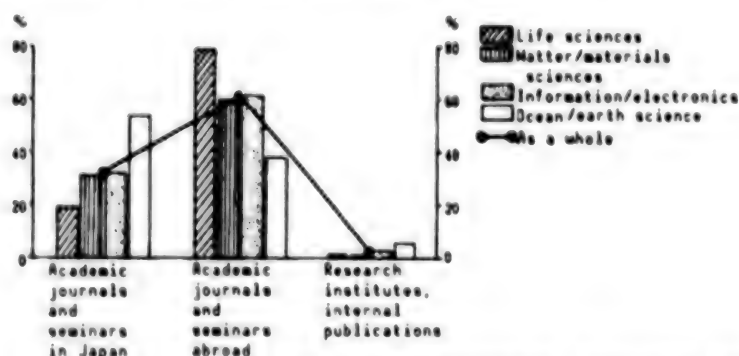


Figure 1-2-59. Sites of Presentation of Important Research Outcomes
Source: "Survey on Frontier S&T Researchers"

With strengthened cooperation between industries, universities and governmental research organs and increased importance in new interdisciplinary research fields, the domestic societies are expected to become increasingly active through society journals with high quality theses and strengthened operational foundations supported by various sectors.

(2) Status of improvement of S&T information activities for creative R&D

Making the distribution of S&T information, such as theses, etc., more sophisticated using information processing, networks, etc., is becoming important in realizing efficient R&D. This concerns the application of data base and computer networks.

Most data bases are constructed on a central computer and accessed from its on-line terminals. However, in the future, researchers may be able to use mass produced data bases in the form of CD-ROM (compact disk read-only memory) on their individual computers.

Distribution networks involving the direct transmission of research information between terminals by personal computer communications, etc., are also increasing.

1) Obtaining S&T information

According to a survey of frontier S&T researchers, 68 percent of the researchers have problems in obtaining research information. These were mainly due to "insufficient time," "lack of traveling expenses and material expenses" and "insufficient information systems and data bases." Categorized by organs, national research institutes indicated "lack of traveling expenses and material expenses" as being the most common cause, while private enterprises saw "insufficient information systems and data bases" as the main cause. In general, "insufficient time" was the largest cause (Figure 1-2-60).

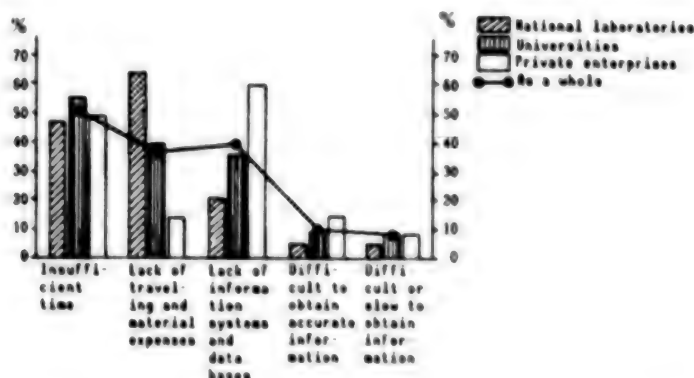


Figure 1-2-60. Problems in Obtaining Research Information
 Note: Multiple answers applied.
 Source: "Survey on Frontier S&T Researchers"

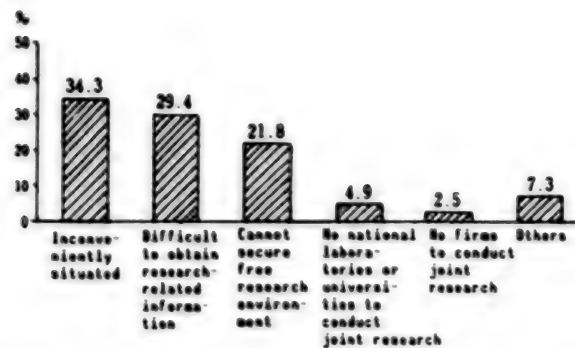


Figure 1-2-61. Inconveniences of Current R&D Base

Note: Multiple answers applied

Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

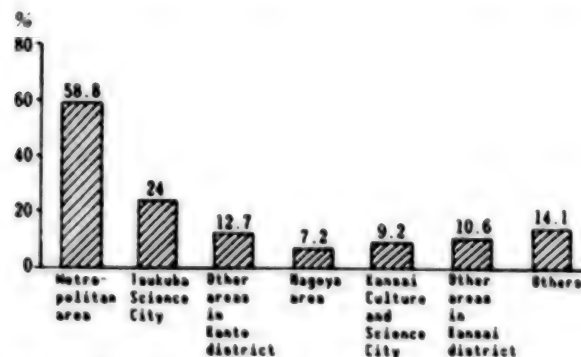


Figure 1-2-62. Proposed Sites of R&D Bases

Note: Multiple answers applied.

Source: "Survey of Research Activities of Private Enterprises (Fiscal 1988)" conducted by Science and Technology Agency

The problems regarding the location of the R&D base of private businesses came from "difficult access" (34 percent) followed by "difficult to obtain information" (29 percent) (Figure 1-2-61). Since the first cause includes inconvenience in obtaining information through meetings and societies, the importance of obtaining information for R&D from others is notable. Asked where they will locate or transfer a new R&D base, 59 percent of the researchers replied "the metropolitan area," while 24 percent replied "Tsukuba Science City." There is a tendency to concentrate in a convenient location and obtaining information (Figure 1-2-62).

With the sophistication of the S&T information distribution system, researchers can spend more time on their original work and obtain wide-ranging information, such as interdisciplinary research outside their specialized field, which helps in achieving higher research efficiency. Information exchange and application will also become easy, regardless of distance, which may ease the concentration of research organs pursuing information.

2) Information distribution through data base

Outside data bases, an important information source for researchers, are utilized by 68 percent of the frontier S&T researchers, among which 85 percent are employed by private businesses. They are used particularly in the life sciences and matter/materials fields (Figure 1-2-63).

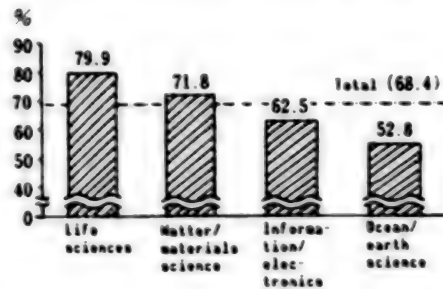


Figure 1-2-63. Use of Outside S&T Data Bases
Source: "Survey on Frontier S&T Researchers"

(Completion of data base)

S&T-related data base service is offered by many organs in Japan, starting with the Japan Information Center of Science and Technology (JICST) and the Academic Information Center. In the JICST, 580,000 document abstracts were planned in FY 1988, and have been increasing yearly. In addition, 5.6 million document files (on overall S&T in Japanese) were accumulated and offered as of May 1988. Meanwhile, the JICST has 500,000 English files in overall S&T (as of May 1988), compared to 8 million data bases mainly involving chemistry in the United States and 3 million data bases of physics, electricity and computers in Great Britain.

A large portion (257 or 57 percent of all data bases) of the S&T data bases available to the public in Japan are from the United States compared to the considerably few 66 (15 percent) from Japan (Figure 1-2-64).

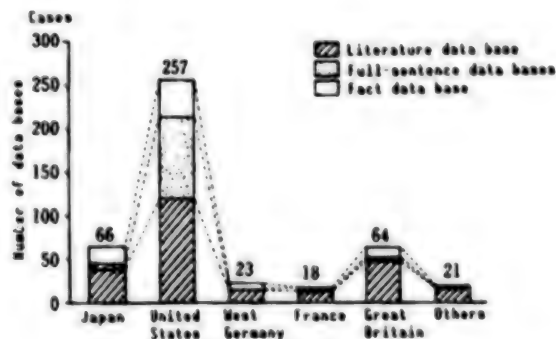


Figure 1-2-64. Comparison of S&T Data Bases Available in Japan
Source: "1987 Edition of Comprehensive Data Base Register"

Accordingly, Japan's data base activities still lag behind those of the Western nations. Although there are some fields in which Japan excels, there are few data bases which can contribute internationally. The expansion of this area is a significant issue.

3) Problems concerning data base application

In addition to the already-mentioned lack of data bases in Japan, problems concerning the application fee, information contents, etc., in the existing data bases are pointed to by the researchers (Figure 1-2-65).

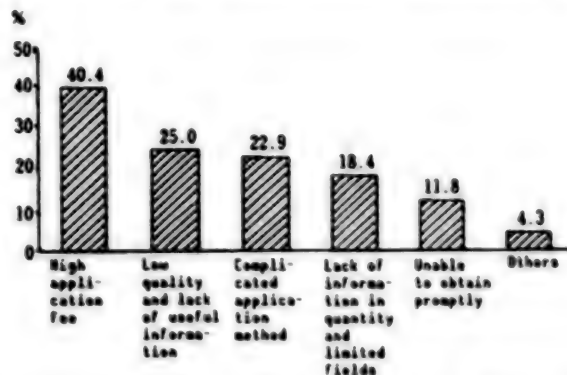


Figure 1-2-65. Problems Concerning Data Base Application

Note: Multiple answers applied.

Source: "Survey on Frontier S&T Researchers"

The greatest problem indicated is the "high application fee." It is thought that the value of the information is generally underestimated, which applies to both the research managers and the users of the information. Since a large initial investment and advanced S&T knowledge are required in constructing a data base, the support of the government and private sector is a requisite for information activities in Japan, which lags behind other nations.

After the application fee problem, the quality and quantity of information is also a great issue as indicated in "low quality and lack of useful information" and "lack of information in quantity and limited fields." Meanwhile, user-friendly information retrieval, the integrated retrieval of multiple data bases, as well as the clarification of accessed organs, are anticipated in order to make data bases more convenient for the users.

4) New distribution system of information

(Network)

Information exchange using personal computer communications, that is, exchanging electronic mail, electronic bulletin boards, etc., through networks connecting personal computers and a central computer has become popular in recent years. Presentations of research outcomes and information exchanges between researchers using this system have also increased. In the

United States, this system has developed since the early 1980s as a network for exchange between researchers. This type of information distribution activity has also become active recently in Japan.

Compared to such activities as the publication of theses or discussions at societies, the advantages include easy use of overseas information through international lines, easy exchange of information even between districts with a large time difference due to the computer's memory, and decrease in unnecessary wasted time from manuscript submission to publication since information can be presented at the same time it is input.

Research information networks which aim at making the most of the R&D potential by maintaining integral cooperation between industries, academia and governmental research organs, both within and outside each district, through electronic mail, electronic bulletin boards, etc., are being planned in Japan at such places as Tsukuba Science City. The Academic Information Center, which is the center of an information network between universities, initiated an electronic mail service in April 1988. There is a plan to connect this network with the United States to promote international exchange.

(CD-ROM)

The CD-ROM, which uses a compact disk as a supplementary memory for the computer, has begun to be applied as a personal data base, due to such advantages as its compactness, large capacity and relatively inexpensive features. Unlike the on-line data base, the information on CD-ROM does not frequently change and can be used for a certain period without being renewed. While it is presently being applied mainly in the fields of dictionaries, maps, etc., it is expected to be used for patent information, which is becoming popular, in addition to S&T information distribution through fact data, etc.

(3) S&T information activities in Japan for international harmony

S&T information activities, such as the contribution of theses, cooperation in data base activities and the exchange of researchers and information, mainly by societies, have been observed from the standpoint of international harmony since their distribution and international harmony is especially important.

1) Japan's S&T documents increasing overseas

A few assessment data regarding each nation's number of theses, etc., have been printed in the world's major society journals. According to the OECD's "Science and Technology Policy Outlook 1988," Japan's share of the number of theses increased markedly from 1975-1985, reaching about 10 percent of that of the OECD nations (Figure 1-2-66). Since this trend is expected to continue for some time, Japan will expand its international contributions in the form of theses, etc., by presenting high quality research results abroad.

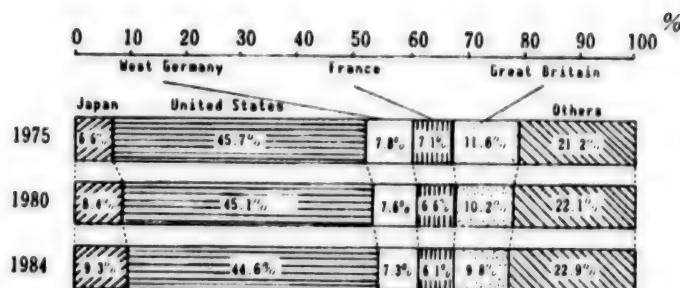


Figure 1-2-66. Ratio of Number of Theses of OECD Nations
Source: "Science and Technology Policy Outlook 1988" by OECD

2) International cooperation in data base activities

It has become common for researchers of various nations to obtain research information from major data bases through international communications lines. In order to promote such activities efficiently and effectively, it is necessary that major organs establish high quality and full-scale data bases, thereby enabling these organs to cooperate with each other. From this standpoint, the Japan Information Center for Science and Technology (JICST), a leading S&T information organ in Japan, constructed an international S&T information network (STN International) in cooperation with the Energy, Physics and Mathematics Information Center (FIZ, Karlsruhe) of West Germany and the Chemical Abstracts Service (CAS), and initiated its services in November 1987. Consequently, a powerful and effective means of supplying Japan's information abroad has been secured. This system is extremely convenient since the individual user can utilize data bases of other organs through this international network by accessing one data base.

In regard to such movements, JICST has been producing a data base of domestic documents with English key words, titles and abstracts, in order to make the international distribution of the information easier.

In order to strengthen S&T information activities, it is essential that the functions of the respective research institutes, along with the central information be strengthened. It is hoped that these research institutes will organize their data into a system so that the information will be open to outside access, will at the same time, be able to exchange information through the network, and will contribute to the world with their research findings.

3) Internationalization of society activities

The society is an important information organ of science and technology involved in distributing research results and supplying a place for research exchange. With the recent increase in S&T information distribution overseas from Japan as well as original research activities in Japan, the other nations' expectations of Japan are increasing. The society serving as the original source of such information is confronted with international demands from developing nations as well as advanced nations.

With respect to the international exchange situation in Japan's societies, many societies are providing titles, names of authors and abstracts in English in order to distribute Japanese theses abroad. Some of them are distributing English theses abroad, while some societies, such as the Applied Physics Society and the Japan Physics Society, generally present papers in English rather than in Japanese. Foreigners are free to participate in the major societies. While they are still few in number, they are increasing. International conferences have especially been increasing recently, mainly affecting the societies that are expected to increase their roles in international exchange. Accordingly, many societies are opening their systems further, on an international basis.

(4) International conditions and S&T information regarding intellectual property rights, etc.

1) Intellectual property and S&T information

Intellectual property involves the historical right to protect the outcome of a person's intellectual and creative activities, including S&T activities, as a property. Such rights as those resulting from basic science and wide-ranging software fields, which should belong to mankind, have become the object of discussion. Since this issue has become even more complex and important, accompanying the sophistication and diversification of technology, it is becoming necessary to confront this problem properly. Items which are currently protected as intellectual properties include computer programs, documents such as data bases, IC chip layouts, and biotechnology-related technology, some of which are closely related to basic research fields.

There are two sides to the relationship between the promotion of S&T activities and intellectual properties.

The first one concerns providing an environment to activate R&D. The proper protection of research results will prevent them from being used commercially without permission and given an incentive to R&D.

On the other hand, the disclosure and application of research results will help to diffuse S&T knowledge and secure the public interest by encouraging the development of new S&T.

Since both of these aspects are important factors in promoting S&T, deficiencies on either side may result in hindering R&D activities. R&D and S&T information distribution can be promoted effectively by fostering these factors harmoniously.

2) International trends

Since technical innovations in such fields as electronics and biotechnology are progressing rapidly due to S&T development, and further intellectual intensification is advancing in the overall industry, movements regarding intellectual properties, etc., are intensifying in the advanced nations. It

is necessary to form an international consensus concerning intellectual properties, etc., not only from the standpoint of commerce, but also to promote active international exchange related to S&T.

In the United States, in particular, the Action Program, a trade policy proposed by former President Reagan in 1985, a protective policy for intellectual properties proposed by the U.S. Trade Representative (USTR) in 1986, and the "Comprehensive Trade and Competitiveness Bill of 1988," which also supports the protection of intellectual properties, can be cited. The following are recent multinational activities which are expected to be involved in alignments and adjustments between nations.

(General Agreement of Tariffs and Trade (GATT) Uruguay Round)

At GATT's Cabinet ministers conference held in Uruguay in 1986, the "trade related side of intellectual properties, including the trade of illegal products" was chosen as an item for new negotiations. They intend to set international regulations regarding intellectual properties to reduce the trade obstacles generated from the inappropriate protection of intellectual properties. Protection standards of intellectual properties and enforcement (administrative and judicial enforcement) are also being considered.

(World Intellectual Properties Organization (WIPO))

The objective of WIPO is to promote the worldwide protection of intellectual properties and secure administrative cooperation between various alliances. WIPO is currently considering an amendment to the Paris Agreement, which is a basic international agreement regarding the protection of intellectual properties, along with an examination of the international harmonization of the patent system, new protective fields involving the latest technology, the prevention of illegal products and the standardization of industrial property-related information. The proper protection of biotechnology inventions by industrial property is also under consideration.

(OECD)

In the general framework of common rules for S&T-related international cooperation, member nations are urged to promote S&T-related international cooperation for economic growth and social development and are also advised to "revise the universal protection of intellectual and industrial properties."

(International alliance related to protection of new varieties (UPOV))

UPOV is an international alliance for the protection of rights of persons engaged in producing new varieties. The influence of high-technology on variety protection, cooperation in making examination procedures efficient, etc., are examined.

(Lateral Patent Agency Conference)

The Lateral Patent Agencies of Japan, the United States and Europe are cooperating in solving common issues efficiently and examining uniformity in the patent system as well as in the operation and exchange of patent information. Similar discussions are also being held at meetings (Club 15) of the member nations of the Europe Patent Treaty (13 nations), in addition to Japan and the United States.

(Japan-U.S.-Europe Tripartite Conference of private sectors)

Corresponding to the GATT Uruguay Round, Japan's Federation of Economic Organization, the Intellectual Property Commission of the United States and the European Federation of Industry (UNICE) met to appeal a tripartite private level agreement to GATT and the governments of various nations. They examined the basic rules for inclusion in GATT's intellectual property agreement from the standpoint of industries, compiling them in a joint paper in June 1988.

The protection of intellectual properties is becoming one of the basic conditions in promoting the distribution of research results and in accumulating them internationally as public assets. On the other hand, creative activities can be encouraged by granting property rights to inventors and authors, and thereby promoting the competitiveness of industries. Consequently, the handling of intellectual properties is an important issue today at a time when science and technology are said to be converging. A harmonious system to protect intellectual properties, etc., is demanded.

Accompanying the increasingly activated, sophisticated and internationalized S&T activities today, S&T information activities are expected to be promoted from a wide perspective.

Part 3. Future Issues and Perspectives

To conclude our analysis, the issues and perspectives for establishing a creative research environment are discussed from an international viewpoint.

1. Various issues affecting strengthened creative R&D

(1) Strengthening basic research and its system

Due to its powerful promotion of technical research, mainly in the application and development fields, Japan has already completed the catch-up process in many fields and has reached a high position in the world today. Considering Japan's national circumstances, science and technology must continue to play an important role in advancing the economy toward the 21st century. Therefore, it is necessary to aim at a higher technical stage and exploit Japan's future progress through S&T, rather than retaining its current position in the world that was established mainly by application and development fields. For this reason, it is indispensable that basic

research, in which Japan is considered to be relatively weak, be strengthened and creative technical seeds be pursued on its own.

It is said that we are in an age in which science and technology are adjacent. The results of basic research are also being applied at a higher pace. In such an age, Japan, which has demonstrated in the past an excellent ability of seeking out technical seeds, nurturing them, and promptly putting them into application, should be able to contribute to the world a greater role in the basic research field. Therefore, from the point of view of establishing a basis for long-term survival and of fulfilling Japan's obligation to the world community, Japan should take up this matter seriously.

However, various conditions must be established as prerequisites to strengthening basic research. Investments in basic research are relatively small in Japan compared to those in the Western nations, and its standards must also aim at a higher level. Basic research, which can fulfill a great role in Japan, must be advanced further than the previously established basic research system and measures.

(2) Revision of research operation and securing capable researchers

(Research operation)

In order to maintain and advance Japan's economic energy based on technical innovation, it is necessary to furnish a research environment conducive to promoting new and creative basic research, while strengthening the present powerful R&D promotion system. As for this research environment, national laboratories, each sector of the industrial circle and national institutes must revise their software through new systems and structures according to their respective roles.

In respect to research management, revisions must be made in national research institutes to shift from placing priority on the organization, to placing it on individuals. Such research management should not be necessarily uniform, but should take an appropriate form for the respective organ, according to its characteristics. In such a case, a relatively free research environment for researchers through flexibility in the organization and expanded discretionary power for the individuals, as well as proper research assessment, from the selection of the research theme to the results, should be the axes of management. A social environment in which capable researchers are permitted to rise from training and management is also becoming necessary. These needs coincide with the consciousness of the researchers.

Meanwhile, the pace of R&D is accelerating even more and basic research in borderline fields and integrated fields is increasing. In such an age, mobile researchers and a system which enables capable researchers to participate in appropriate research opportunities and places at an appropriate time, according to research needs, are demanded.

(Securing qualified personnel)

It is indisputable that the foundation of the current technical progress was laid by many organized and capable researchers. While the number of research personnel has increased consistently in the past 20 years, the lack of qualified personnel, both in quantity and quality particularly in the industrial world, has become conspicuous with the activation of R&D activities. Recently a sense of shortage in private enterprises has been evident due to movements to emphasize technology in business management and to strengthen basic research throughout Japan.

Therefore, it is necessary to cope with such demands in researchers. Particularly in basic research, which places greater expectations on individual abilities rather than on the organization, securing capable researchers from various sectors is an urgent problem. High expectations are being placed on universities, whose major duty is to nurture personnel along with conducting academic research.

The tendency of the young people, such as science and engineering university students, to move away from the manufacturing industry has been noticeable. In order to secure sufficient researchers both in number and capabilities, in the future, it is necessary to improve personnel treatment as well as to provide an attractive research environment.

(3) Furnishing of research infrastructures

In realizing such strengthened basic research and an established research environment, improved software and suitable research infrastructures for the new age are requisites.

One aspect involves the completion of R&D facilities and equipment. Due to the sophistication of basic research today, the facilities and equipment sometimes determine the S&T standards and often influence the outcome of basic research. Japan has almost reached Europe in respect to facilities and equipment, and ranks with the United States in some flow parts. However, basic research is predicted to become even more sophisticated, along with the multipolarization of S&T activities and technological globalization. Consequently, Japan must make its research facilities and equipment more sophisticated to strengthen its basic research and to cope with the internationalization of S&T.

Another infrastructure matter concerns improved research efficiency and strengthened information activities for the smooth distribution of research results. Some sophisticated means of obtaining and effectively applying information is essential for researchers when promoting research today. While a considerable quantity of individual research results has been generated in Japan, information activities to accurately process, distribute and make use of these results in research, as well as to conduct international exchange on equal terms, are still behind those of other nations. Therefore, it is necessary to promote data base activities, as well as the extensive diffusion and application of sophisticated information

activities. Visits and correspondence between nations have become a daily matter with the advancement of transportation and communications means. Japan must take advantage of its geographical and environmental features and strengthen the basic information activities by such means as inviting many researchers and holding international conferences.

2. Development of an Open Research State

(1) Internationalization of S&T system

With Japan's position in the S&T field rising, its international conduct is becoming quite influential. The development of policies and S&T activities, bearing international harmony in mind, are becoming necessary since Japan is expected to continue to expand its R&D activities.

Efforts have already been made in Japan to open its research system overseas. Industries, universities and governmental organs are making efforts to participate in exchanges with overseas nations by such means as facilitating access to their research systems and receiving numerous foreign researchers.

However, while raising the level of research standards in Japan is a prerequisite for future progress, strengthened research facilities and an improved exchange system are also essential. An effective method is to equip internationally attractive research facilities which will gather capable researchers. Possessing such facilities and equipment, along with offering flexible operation, may lead to a "Center of Excellence."

A supportive system is indispensable in promoting exchange with overseas nations, whether they are advanced or developing nations, and for realizing better communications with the world. It is also necessary to start using the Law To Promote Research Exchanges, establish a readily accessed exchange system and improve the living environment for exchange researchers. Along with such efforts by Japan, it is also expected that other nations deepen their understanding of Japan's S&T environment, including cultural tradition, to improve access to Japan.

Through such measures and activities, domestic and overseas researchers can be exchanged and researchers can be widely accepted from overseas nations, which will help expand the international intellectual assets. It will also contribute to training people, mainly in developing nations, as well as to the advancement of S&T in Japan on a long-term basis.

(2) Promotion of competition and cooperation

For the past several decades, the United States has consistently been the world's leader in frontier S&T. The United States has acquired this position by engaging in multiple measures to strengthen S&T, such as by establishing numerous major research organs early on, providing abundant capital investments, emphasizing scientific research in universities, and inviting many internationally prominent researchers. However, the United States' standing has relatively declined, due to an enormous financial deficit and

a slowdown in investment interests in the industrial circles. This tendency is also seen in the basic research field. In addition, in the midst of rapid technological changes, the tendency to aim at strengthened technical competition and emphasis on basic research in Europe is becoming uncertain. The international situation concerning intellectual properties is that, while it basically involves protecting the rights between advanced nations and developing nations, it also contains an element which may hinder the advancement of S&T, depending on how it is enforced. In view of such a severe international situation, it will become necessary for Japan, the United States and Europe to cooperate, cope with their respective needs within each district, according to their respective features, and execute the apportionment of roles and duties according to their means. Since Japan will be given an important role, the international viewpoint based on competition and cooperation will become Japan's indicator.

Accordingly, Japan must realize long-term advancement by strengthening basic research, etc., while fulfilling its demanded international role by furnishing internationally-open facilities and equipment, exchanging and receiving capable talent, and generating and distributing basic research results. Japan must also actively propose projects, such as the Human Frontier Science program or the Space Station Project, promote international cooperation, and take the initiative appropriate for its national strength at a time when S&T is becoming of a larger scale and Japan's role in basic research is rising.

The globalization of technology is making S&T activities become common deeds of mankind, whether in advanced or developing nations. This will further increase the exchange of personnel and information between nations, but will also intensify the international competition in technology. In such a new age, Japan must develop measures from the standpoint of competition and cooperation, based on such proposals as the "Pressing International Issues Regarding S&T," a report by the Meeting on International Issues of the Policy Committee of the Scientific and Technical Council

3. Conclusion

It is being demanded that Japan play a greater international role and accept greater responsibility today, due to the expanded scale of S&T activities in Japan and the achievement of extremely high technical standards on an international basis. Japan must promote creative R&D, mainly in the basic research field, and furnish the required research environment to maintain its own development. It is also necessary to develop a comprehensive policy from an international perspective and promote proper S&T activities, while acknowledging the considerable influence of its conduct in the world.

Chapter II. Science and Technology Activities in Japan

Part 1. Research Activities

The importance of developing science and technology (S&T) is ever increasing in order for the living standard of the people to be improved qualitatively by attaining a stable growth of the economy through international cooperation, and, at the same time, tackling Japan's numerous problems involving natural resources, energy, the environment, safety, the increasing number of aged people and the trade friction. Under these circumstances, Japan must increasingly step up research investments and assistance to researchers so that the various problems standing in the way of the development of S&T, can be resolved.

In this part, this white paper will review the research activities¹ in Japan by comparing them with the situations in foreign countries. First, the research activities will be outlined, followed by a description of research activities at corporations, research institutes and academic organizations, respectively.² (Footnote 1) (The fields of research activities will be confined to natural sciences, excluding cultural and social sciences. Excluding universities, distinction between natural sciences and cultural-social sciences will be made by taking a single institution as the smallest unit for the distinction. (In the case of universities, the distinction will be made by faculty.)) (Footnote 2) (The term corporations will refer to the ones capitalized at higher than ¥1 million before 1974, higher than ¥3 million between 1975 and 1978, and higher than ¥5 million after 1979, and other special corporations, including the Japan Broadcasting Corp. (NHK) and the Japan Highway Public Corp. The term research institutes refers to both public and private research organizations, including the National Space Development Agency, the Power Reactor and Nuclear Fuel Development Corp., the Japan Atomic Energy Research Institute and the Institute of Physical and Chemical Research. The term academic organizations includes the faculties of universities and graduate schools, junior colleges, five-year technical schools, research institutes attached to universities, the University Entrance Examination Center, and those institutions which are shared by national universities.)

1. Overview of Research Activities

(1) **Research expenditures**³ (Footnote 3) (In calculating research expenditures, there are two methods of calculation. One is to combine the researchers' salaries, material procurement costs, equipment and other research-related asset procurement costs and the other miscellaneous costs incurred while conducting research by Japan's researchers. The other is a calculation method in which the cost for procurement of equipment and other research-related assets is replaced with their depreciated values. In this paper, the former will be used.)

The aggregate of research expenditures is an indicator of the research activity level. In FY 1986, the total research expenditures in Japan stood at ¥8.415 trillion,⁴ an increase of 3.7 percent over the ¥8.1164 trillion

expended in FY 1985. In terms of the real values of research expenditures, the growth nearly leveled off during the 1974-75 period, but began to increase in 1976 and continued to rise through 1986 (Figure 2-1-1). (Footnote 4) (This amount represents the research expenditures in natural science fields. Just for purposes of comparison, the expenditures in the fields of cultural and social sciences in 1986 stood at ¥777.9 billion, accounting for 9.2 percent of the expenditures for natural sciences.)

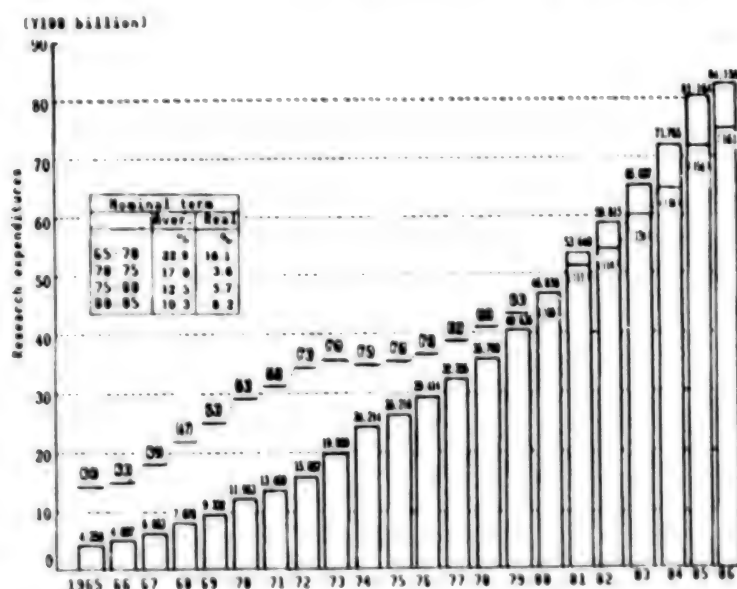


Figure 2-1-1. Growth of Research Budget in Japan

Notes: 1. Figures in () are indexes of research expenditures in real terms (1980=100)

2. The deflators are based on the attached material.

Source: "Report on S&T Research" compiled by the Statistics Bureau, Management and Coordination Agency

An international comparison of research expenditures is difficult to make because the ways of calculating the amounts of expenditures differ from country to country. However, by comparing them, it is possible to grasp rough levels of the amounts of expenditures. According to the comparison, the United States far outdistances other major industrial countries, and is followed by Japan, the Soviet Union and West Germany (Figure 2-1-2).

A comparison of real-term research expenditures among Japan, the United States, West Germany and France since 1980 shows that Japan has registered the steepest growth in expenditures (Figure 2-1-3). West Germany has also registered a comparatively steep growth, but since 1981 it has dropped to third place, following France.

The level of a country's research expenditures can be represented by the ratio of the expenditure to the gross national income of that country's populace. Internationally, during the years from around 1971 to 1978, there were no significant fluctuations in the ratios of those major countries.

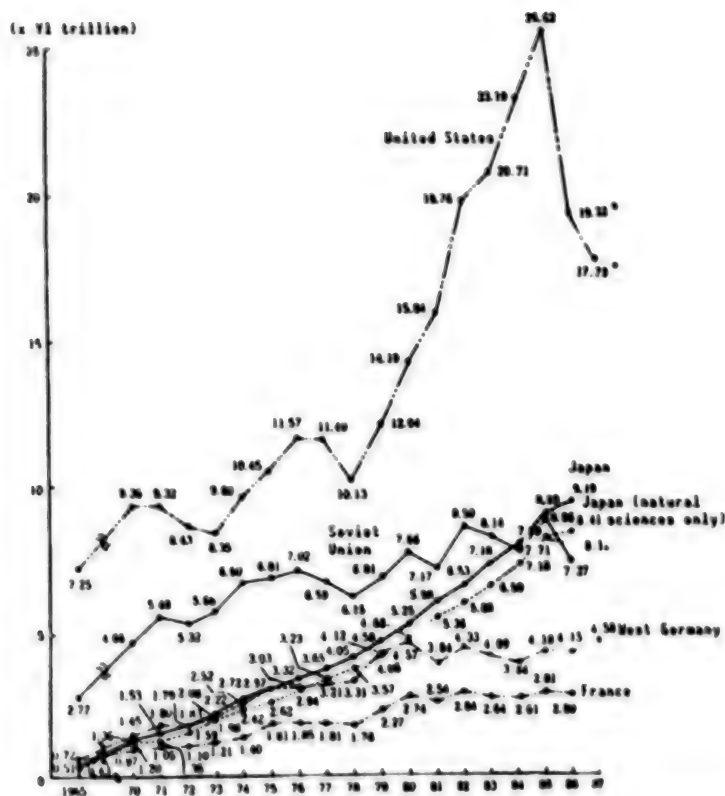


Figure 2-1-2. Growth of Research Expenditures in Major Countries

- Notes: 1. The amounts of research expenditures for each country include the expenditures for cultural and social science field research. However, for Japan, the expenditures for the research in natural science fields are also shown.
2. "*" represents an estimated value and "□" a preliminary value.
3. Conversions of the expenditure values into yen were made based on the attached material No 33.

Sources: Japan--"Report on "S&T Research" compiled by the Management Coordination Agency
 United States--"National Patterns of Science and Technology Resources" by NSF
 West Germany--"Bundesbericht Forschung 1988" by the Ministry of Research and Technology
 France--Appendix to draft budget
 Soviet Union--"Yearbook of Statistics of Soviet Domestic Economy" prepared by the Central Statistics Bureau attached to the USSR Council of Ministers

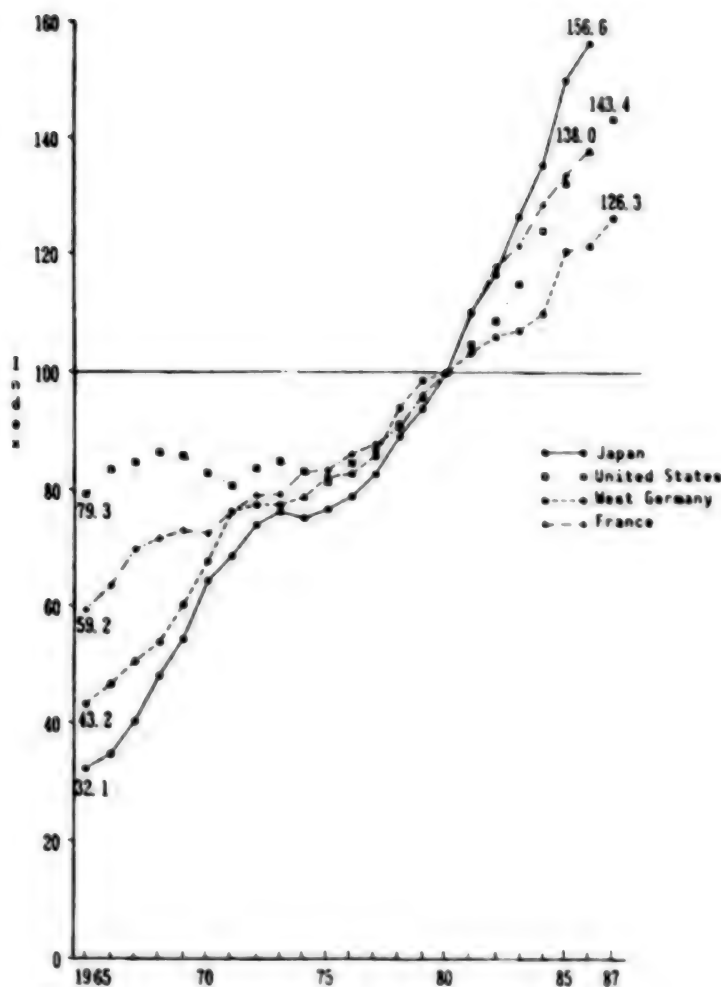


Figure 2-1-3. Growth of Real-Term Research Expenditures in Major Industrialized Countries

- Notes: 1. Expenditures for each country include those for cultural and social science research.
 2. Refer to appendix material 32 [not reproduced] for the deflators.
 3. Index--1980=100

Source: Same as Figure 2-1-2.

However, the ratios began to resume a steady climb in those countries around 1979. Among them, Japan has recorded marked growth: in 1986 it chalked up a 3.47 percent increase in the ratio when including cultural and social science research expenditures, and a 3.18 percent gain when only natural science expenditures were included.

In November 1984, in its 11th report on the long-term policy for the promotion of science and technology in Japan, the Council of Science and Technology recommended that Japan, for the time being, try to attain a research expenditure-to-national income ratio of 3 percent, while afterward

aiming at 3.5 percent as a long-term goal in natural science research. However, some time has passed since attaining the initial goal, and attention is now shifting to when it can attain the higher target (Figure 2-1-4).

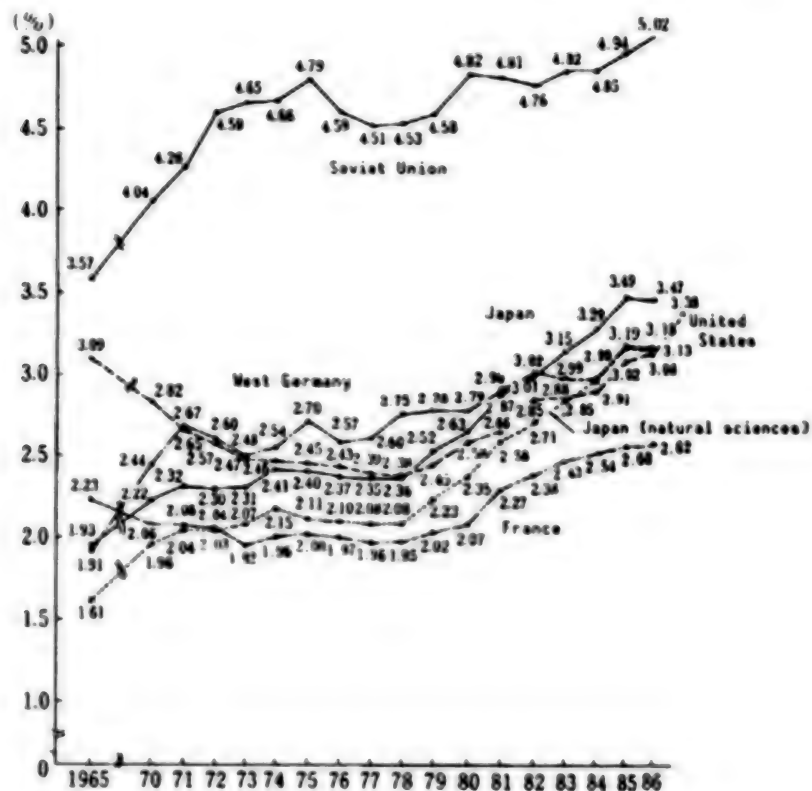


Figure 2-1-4. Growth of the Ratios of Research Expenditures to National Incomes in Major Countries

Note: The ratios were calculated by including cultural and social science research expenditures. In the case of Japan, the ratios for natural science expenditures alone are also shown.

Source: Refer to Figure 2-1-2. For national incomes, see appendix material 1.

This fast progress is believed to have been realized as a result of Japan's recognition of the importance of promoting S&T research years ago, due to the various international as well as domestic developments unfavorable to Japan in recent years, and as a result of stepped-up R&D efforts. Particularly, the private sector institutions have contributed greatly to the progress by stepping up R&D investments. In addition, the government's efforts to appropriate S&T-related money and its lengthy efforts to promote S&T research in the private sector have aided the progress.

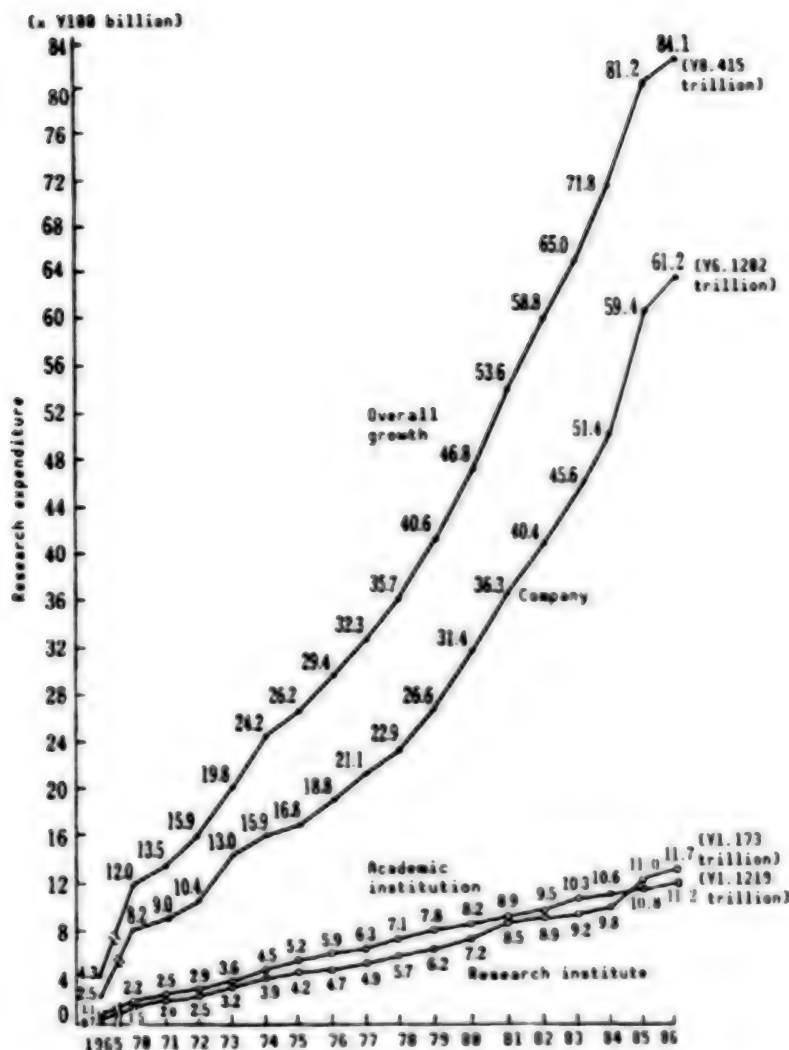


Figure 2-1-5. Growth of Research Expenditures by Category of Research Establishment

Source: "Report on S&T Research"

(Research expenditures by category of establishment)

By category of research establishment, private sector corporations reached the top regarding amount of expenditures by expending Y6.1202 trillion in FY 1986, a gain of 3 percent over the previous year. This amount accounted for 72.7 percent of Japan's total research expenditures during that year. They were followed by research institutes, with Y1.173 trillion (accounting for 13.9 percent and an increase of 6.5 percent), and academic institutions, with Y1.1219 trillion (13.3 percent and a gain of 4.3 percent), respectively (Figure 2-1-5).

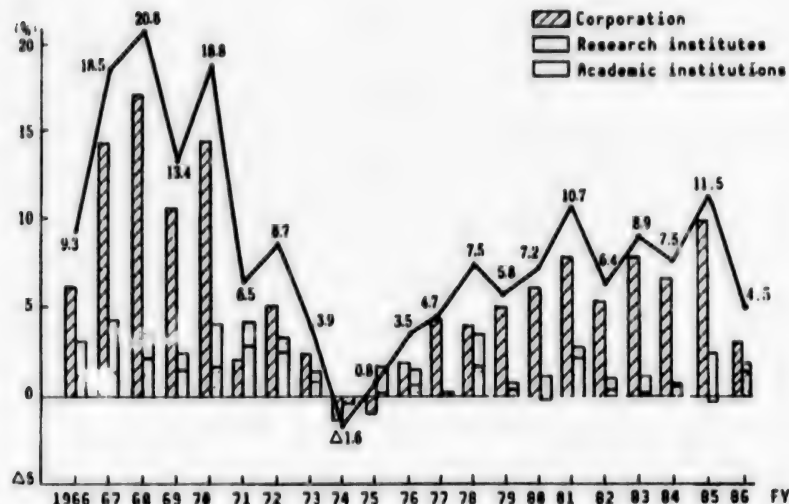


Figure 2-1-6. Shifts in the Degree of Contributions to the Year-to-Year Growth Rate of Real-Term National Research Expenditures in Japan by the Research Institutes in Three Separate Sectors

Note: The deflators are based on the information in appendix material 32.

Source: "Report on S&T Research"

By observing the relationships between the growth of aggregate research expenditures and that of research expenditures according to the type of research establishment based on the year-to-year growth of real-term research expenditures and the contributions made by those establishments, it can be found that fluctuations in research expenditures in Japan have been influenced greatly by the expenditures of the private sector companies. In the latter half of the 1960s when Japan was booming with high economic growth, sharp increases in aggregate research expenditures were registered as a result of sizable increases in corporate research expenditures. However, the growth rate in aggregate expenditures began to slow down around 1971, and in 1974 and 1975 the year-to-year real-term growth rate in corporate research expenditures turned to minus rates, due partly to the aftereffects of the oil crisis. This caused the year-to-year growth rate of Japan's total research expenditures to also decrease substantially. However, starting in 1976, the corporate research expenditures again began to increase gradually, significantly raising the total national research expenditures (Figure 2-1-6).

(Percentage of shouldering research costs)

In FY 1986, the year's research costs in Japan were shouldered 19.6 percent (¥1.6517 trillion) by the government (central and local governments), 80.3 percent (¥6.7557 trillion) by private sector companies and 0.1 percent (¥7.6 billion) by foreign entities (Figure 2-1-7).

	Government	Private sector
1965	30.8%	69.1%
1970	33.3%	66.7%
1975	27.5%	72.4%
1976	27.2%	72.7%
1977	27.4%	72.5%
1978	28.0%	71.9%
1979	27.4%	72.5%
1980	25.8%	74.1%
1981	25.0%	74.9%
1982	23.6%	76.3%
1983	22.2%	77.7%
1984	20.8%	79.1%
1985	19.4%	80.5%
1986	19.6%	80.3%

Figure 2-1-7. Shift in the Percentage of Shouldering Research Expenditures

- Notes: 1. The government includes both the central and local governments.
2. In addition to expenditures by government and private sector companies, research funds also came from foreign countries, with the sum accounting for about 0.1 percent of the yearly gross research expenditures.

Source: "Report on S&T Research"

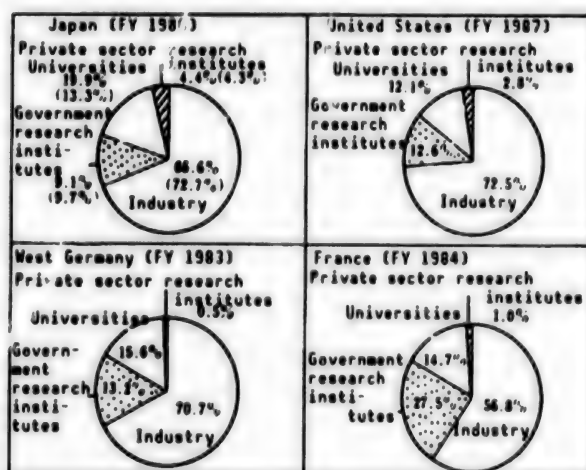


Figure 2-1-8. Research Money Shares of Separate Research Sectors in Major Industrialized Countries

- Notes: 1. The percentage figures include cultural and social science research expenditures.
2. The figures for the United States are estimated.

Sources: Japan--"Report on S&T Research"
 United States--NSF "National Patterns of Science and Technology Resources"
 West Germany, France--OECD statistics

In major industrialized countries, about two-thirds of the yearly gross national research money is expended by industry (Figure 2-1-8).

Regarding the flow of research money among industry, academia and government research institutes, the level of flow is comparatively low in Japan compared with that in other countries (Table 2-1-9). The principal reason for this is that, in Japan, each of the three separate research segments has tended to confine its activities to within itself, and they have had little contact with other research segment organizations. As opposed to the situations in other countries, in Japan private sector companies are expected to play major roles in R&D activities, and this is an element impeding the flow. The United States has a higher flow level by sharing the defense-related research money.

Table 2-1-9. Flow of Research Money Among Industry, Academic Research Institutes and Government Research Establishments in Major Industrialized Countries

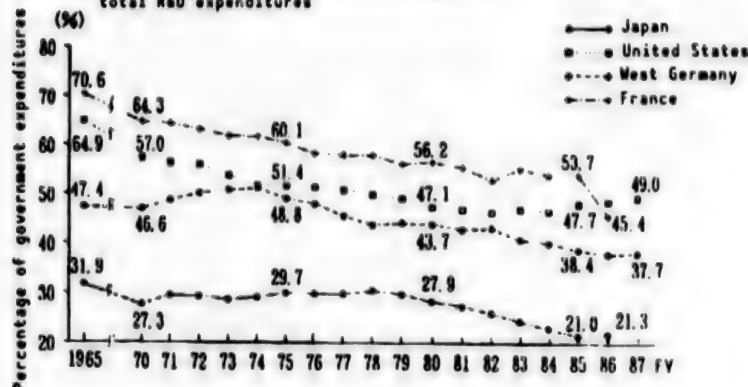
Source of research money	Beneficiary	Japan (FY 1986)		United States (FY 1987)		West Germany (FY 1985)		France (FY 1983)	
		Amount	Share	Amount	Share	Amount	Share	Amount	Share
		V100 million	%	V100 million	%	V100 million	%	V100 million	%
Government	Industry	1,100	1.8	31,700	35.5	4,953	15.3	3,361	22.4
	Government	7,911	94.1	15,450	100.0	1,430	95.5	6,663	95.6
	University	9,653	52.7	10,800	72.2	5,359	93.7	4,078	97.6
Industry	Industry	59,901	97.9	57,500	64.5	26,998	83.3	10,940	73.0
	Government	489	5.8	0	0	* 49	3.3	48	0.7
	University	309	1.7	670	4.5	302	6.3	54	1.3

- Notes: 1. The figures in the list include cultural and social science research expenditures.
 2. The percentage represents the share of each research sector in the sum of research money available.
 *: Including an amount shouldered by private sector research institutes.

Sources: Japan--"Report on S&T Research"
 United States--NSF "National Patterns of Science and Technology Resources"
 West Germany--BMFT "Bundesbericht Forschung 1988"
 France--OECD statistics

In Japan, the weight of defense-related research money from the government is low compared to that in other countries. It is difficult to make an accurate comparison due to the differences in tax burdens and the ability of the private sector in each country to shoulder research expenditures, but the percentages of research money coming from the governments were 57.7 percent in the United States (FY 1987), 45.4 percent in France (FY 1986), 37.7 percent in West Germany (FY 1987) and 21.3 percent in Japan (FY 1986). The percentage in Japan included cultural and social science research expenditures, while when they are excluded, the percentage decreased to 19.6 percent (Figure 2-1-10). Over the past several years, the percentage has

(1) Percentage of government expenditures against total R&D expenditures



(2) Percentage of government expenditure excluding defense research expenditures

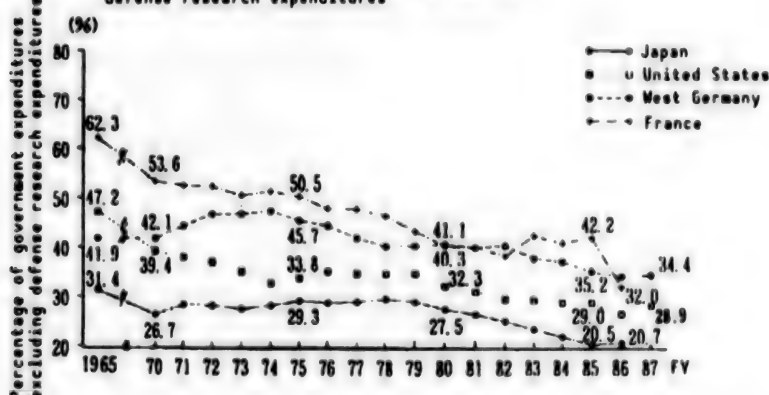


Figure 2-1-10. Variations in the Amounts of Government Expenditures on R&D in Major Industrialized Countries

- Notes: 1. For defense research expenditures in these countries, refer to appendix material 1.
2. Government expenditures excluding defense research expenditures =

$$\frac{\text{Amount of government research money} - \text{Defense research expenditures}}{\text{Research expenditures} - \text{Defense research expenditures}} \times 100$$

3. Percentages for FY 1986-87 in the United States are estimates
4. Percentage excluding defense related expenditures for FY 1987 in West Germany is a preliminary one
5. Percentage figures above include cultural and social science research expenditures

Sources: Same as Figure 2-1-9.

been decreasing gradually in these industrially developed countries. The main reason for this is due to the sustained increases of R&D investments by industry in these countries.

The percentages of government expenditures excluding defense research expenditures in these major countries are: West Germany 34.4 percent, France 32.0 percent, the United States 28.9 percent and Japan 20.7 percent (including cultural and social science research expenditures). In the case of Japan, the figure goes down to 19 percent when the government processes are confined to natural sciences (Figure 2-1-10).

(Research expenditures by type of cost)

Research money is expended to pay salaries to researchers, to procure various assets needed for research (land plots, buildings, mechanical facilities, equipment, etc.) and to pay other research-related costs. Among these items of expenditures, the researchers' salaries are dominant. During the first half of the 1970s this ratio continued to rise, until it began to decline in 1975. In FY 1986, the ratio stood at 42.8 percent.

The costs for procuring materials have increased slightly during the past several years. In FY 1986, the percentage of procurement costs stood at 18.5 percent, against 17.3 percent for procurement costs of various assets.

Other miscellaneous costs, including expenditures for buying books, traveling, communications and office expenses, have been leveling off during the past several years, and in FY 1986 they stood at 21.4 percent (Figure 2-1-11).

Regarding the contents of expenditures, at private sector companies the costs for securing materials are comparatively higher than those at research institutions in other sectors, at research institutes the costs for procuring various research-related assets dominate, and at academic institutions researchers' salaries overwhelm other expenditures (Figure 2-1-11).

(Research expenditures by character of research)

In FY 1986, expenditures in the field of applied research declined slightly from the preceding year, while expenditures in the fields of basic research and development research increased.

The ratios of these expenditures for private sector companies, research institutes and academic institutions, respectively, reveal their nature as research entities. That is, at private sector corporations, the weight of expenditures in development research is overwhelmingly large as a result of their efforts to develop new products, whereas academic institutions put an emphasis on basic and applied research and research institutes lie between these two (Figure 2-1-12).

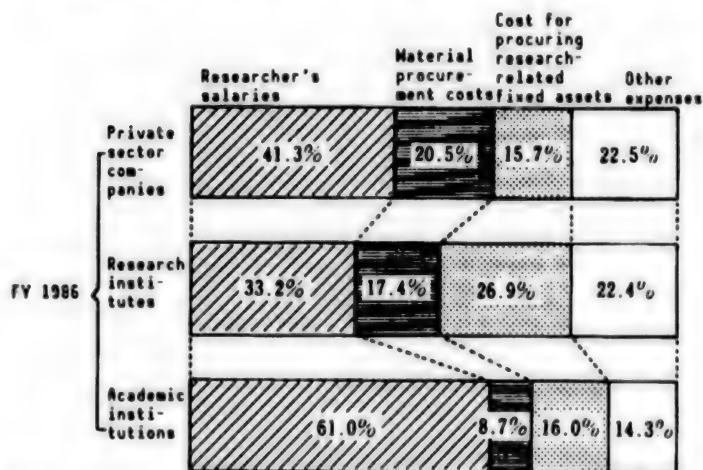
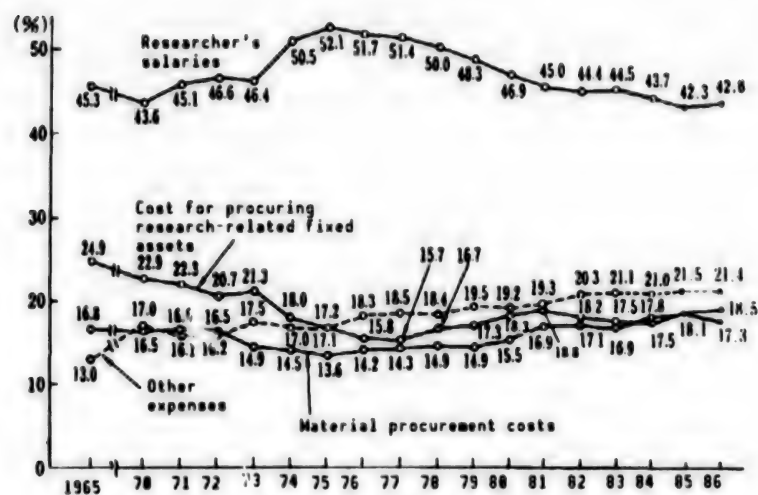


Figure 2-1-11. Shift in the Amount of Research Expenditures by Type of Cost
Source: "Report on S&T Research," Statistics Bureau, Management Coordination Agency

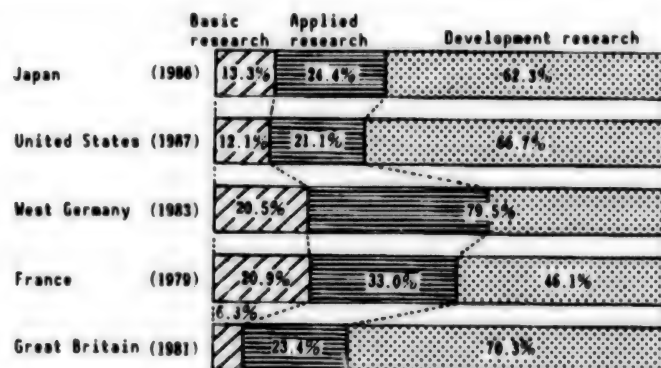


Figure 2-1-12. Research Expenditures by Character of Research
Source: "Report on S&T Research"

By country, the weight of development research is comparatively large in the United States, while the weight of basic research is fairly large in West Germany and France. Japan is situated between these two camps (Figure 2-1-13). Great Britain is excluded from the comparison because the information available excludes university data.

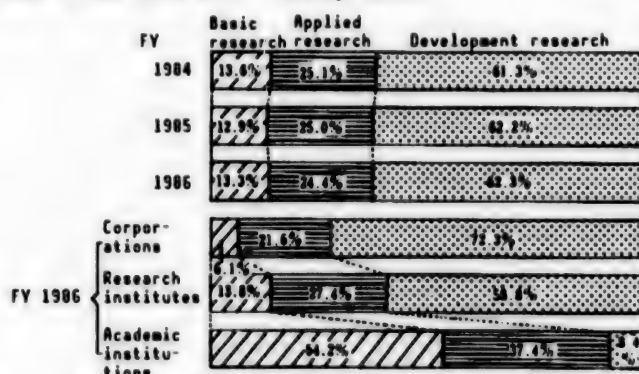


Figure 2-1-13. Research Expenditures by Type of Research in Major Industrialized Countries

- Notes: 1. The percentage figures for Japan, West Germany and Great Britain are for natural sciences only, corresponding figures for the United States and France include cultural and social science research expenditures.
 2. In West Germany no distinction is made between applied research and development research.
 3. The West German figures exclude private sector research institutes.
 4. The British figures exclude universities.

Source: Refer to Figure 2-1-8. OECD statistics are used for Great Britain

(Research expenditures by specific purpose)

In FY 1986, Japan expended a total of ¥1.2536 trillion for research in the fields of nuclear development, space development, marine development, information processing and environmental protection (Footnote) (Represented by the term "pollution prevention" in the "Report on S&T Research."), an increase of 9.9 percent over the preceding year. This sum represented 14.9 percent (14.1 percent in FY 1985) of Japan's total research expenditures that year. In terms of the amount of research money expended, information processing (an increase of 9.7 percent over the preceding year) is at the top, followed by nuclear development (a gain of 14.7 percent), space development (a gain of 4.4 percent), environmental protection (an increase of 1.1 percent) and marine development (a gain of 24.7 percent), in that order (Figure 2-1-14).

The amount of expenditures for energy development, including nuclear energy, in FY 1986 reached ¥822.6 billion. Eleven percent of the sum went to research toward the utilization of fossil energy, including petroleum, natural gas and coal, 4 percent to the development of natural energy, i.e.,

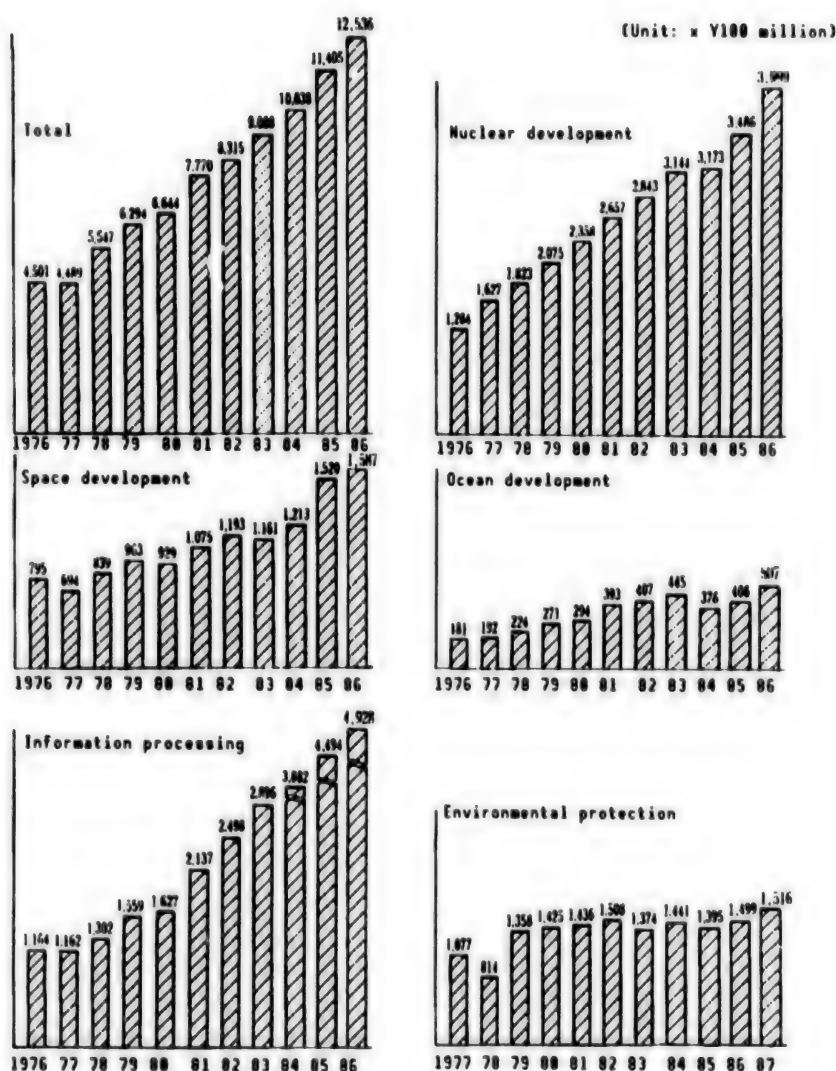


Figure 2-1-14. Shift in Research Expenditures in Specific Fields of Research

Note: Corporations covered in the investigation were capitalized at higher than ¥100 million.

Source: "Report on S&T Research," Statistics Bureau, Management Coordination Agency

solar and geothermal energy, 48.6 percent to the research of nuclear energy, 33.8 percent to energy conservation, and 2.6 percent to research on other types of energy. Corporations fetched the largest amount of research money for research on fossil energy, natural energy and energy conservation. In the research of nuclear energy, research organizations secured a larger sum. In the research of fossil energy, petroleum-related research fetched the largest chunk of money while in natural energy development, solar energy development claimed the largest sum, in nuclear energy research emphasis was

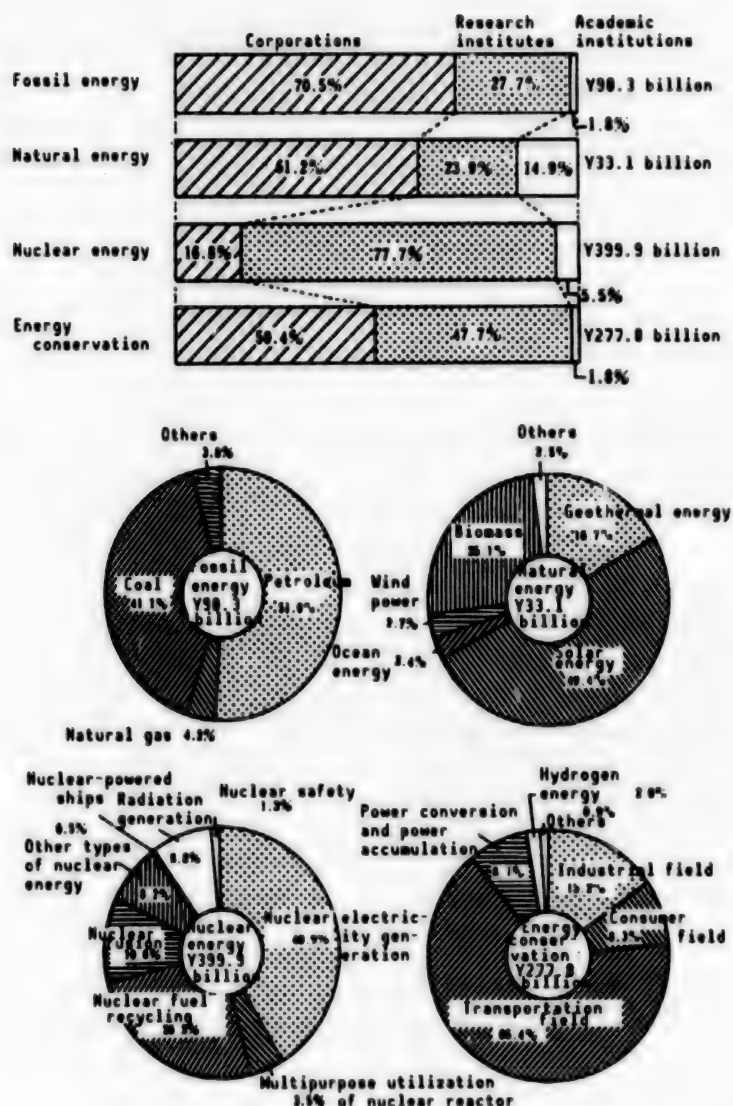


Figure 2-1-15. Breakdown of the Expenditures in Energy Development Research (FY 1986)

Note: Corporations covered in the investigation were capitalized at higher than ¥100 million.

Source: "Report on S&T Research"

placed on nuclear electricity generation, and in the research for energy conservation the largest sum went to transportation-related research (Figure 2-1-15).

Turning to the expenditures in life science research, a total of ¥909.6 billion was used in FY 1986. Seventy percent of the sum went to the research related to public health and medical care (Figure 2-1-16). For the research involving gene recombination, a sum of ¥43.5 billion was used, accounting for 4.8 percent of the total life science research expenditures.

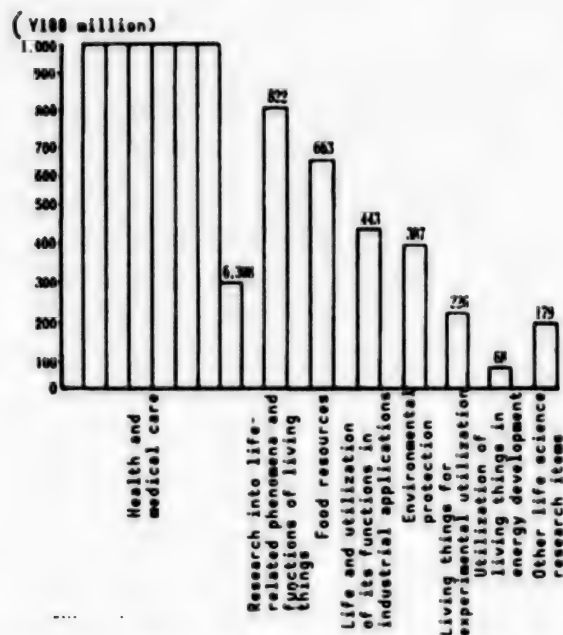


Figure 2-1-16. Expenditures in Life Science Research by Field of Research (FY 1986)

Source: "Report on Life Science Research" compiled by the Statistics Bureau, Management Coordination Agency

(Research expenditures per researcher)

In FY 1986, the money expended by a Japanese researcher stood at ¥20.75 million, a decline of 2.5 percent from the preceding year.

In the first half of the 1970s, the real-term research expenditures per researcher continued to decrease due to the steep inflation following the oil crisis. However, these expenditures turned to a moderate but sustained increase in the latter half of the 1970s. But in FY 1986, the real-term expenditures stood at ¥18.54 million, a decline of 1.8 percent from the year before (Figure 2-1-17).

By research sector, research institutes enjoyed the highest per-researcher expenditures with ¥36.14 million in FY 1986, followed by corporations with ¥24.31 million and academic institutions with ¥9.25 million. The per-researcher expenditures for research institutes represented a gain of 5.6 percent over the preceding year, and for academic institutions a meager 1.5 percent increase, respectively. However, for corporations, the amount for the fiscal year represented a decline of 5.4 percent (Figure 2-1-17).

It is difficult to make an accurate comparison among major countries partly because of the differences in research systems, but per-researcher expenditures in Japan stood at ¥19.42 million (FY 1986 and ¥20.75 million for natural sciences only), in West Germany at ¥29.11 million (FY 1985), in France at ¥27.48 million (FY 1985), and in the United States at ¥24.09 million (FY 1986), respectively (Figure 2-1-18).

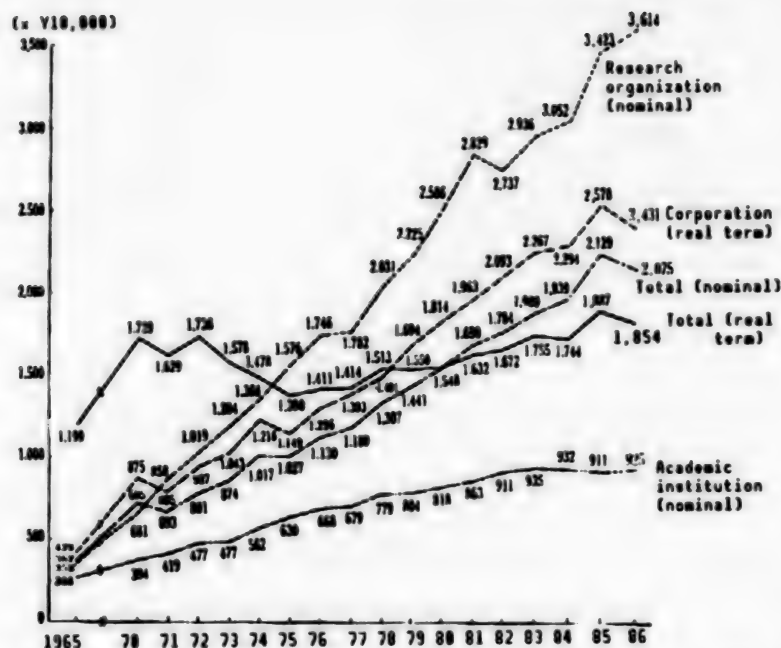


Figure 2-1-17. Shift in the Amount of Research Expenditures Per Researcher

Note: The amount of research expenditure per researcher was calculated by dividing the total research budget for a single fiscal year by the number of active researchers on 1 April of that year, the first day of the fiscal year. As for the graph of total expenditures (real term), the reference point is set at FY 1980.

Source: "Report on S&T Research"

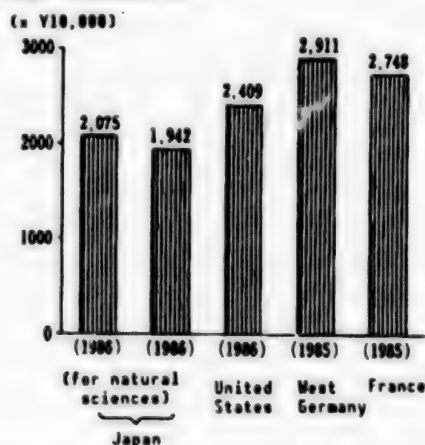


Figure 2-1-18. Per-Researcher Expenditures in Major Industrialized Countries

- Notes: 1. The amounts of per-researcher expenditures for these cultural and social science research expenditures in addition to natural science research expenditures. For Japan the amount excluding cultural and social science research expenditures is also shown.
2. The U.S. figure is an estimate.
3. Conversion to the yen was made based on the appendix material 33.

Source: Refer to Figure 2-1-13. For West Germany, OECD statistics were used.

(2) Research personnel

The research institute staff can be classified into researchers, research assistants, technical specialists, personnel handling research-related business affairs, and those in charge of other research-related affairs.¹ In this white paper, the term researcher refers to those who are devoted to research and do not handle other research-related business simultaneously. (However, the term research expenditure involves the money expended for hiring those who will be engaged in research and other business simultaneously.) Research assistant: Those who work under researchers, assisting them with their research, and have the possibility of becoming full-fledged researchers in the future. Technical specialist: Those who provide researchers and research assistants with technical service related to their research under their supervision. Business affair personnel and others: Mainly those who are engaged in the businesses of accounting and other general affairs related to research.) (Footnote 1) (Researcher: Those who graduated from universities (excluding junior colleges) and have been engaged in research on a specific subject for more than 2 years (or those who have knowledge equivalent to such researchers.)

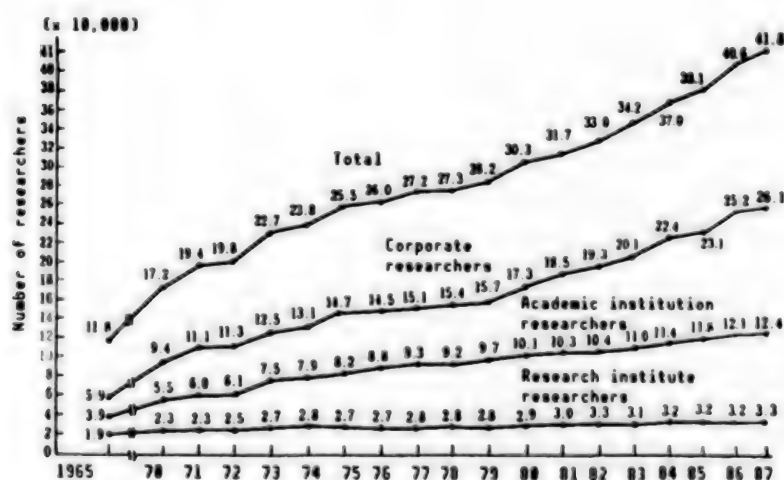


Figure 2-1-19. Shift in the Number of Researchers

Note: The numbers of researchers are as of 1 April of those years.

Source: "Report on S&T Research"

(Number of researchers)

As of 1 April 1987, the number of researchers in Japan totaled 418,000, an increase of 3.2 percent over the 406,000 the preceding year (Figure 2-1-19).

Since 1965, the number of researchers increased continually on a yearly average of 7.9 percent from 1965 to 1970, 8.2 percent from 1970 to 1975, 3.5 percent from 1975 to 1980, 4.7 percent from 1980 to 1985 and 4.7 percent from 1985 to 1987. In the latter half of the 1970s the growth rate slowed down

a little, but in the first half of the 1980s it began to increase at a relatively high rate again.

By research sector, in FY 1987 the number of corporate researchers stood at 261,000 (an increase of 3.6 percent over the preceding year), accounting for 62.4 percent of the total number of researchers in Japan. This was followed by academic research institutions with 124,000 (a gain of 2.4 percent), accounting for 29.7 percent, and research institutes with 33,000 (an increase of 2.5 percent), representing 7.9 percent, respectively (Figure 2-1-19).

It is difficult to make an accurate comparison of the number of researchers among major countries due to differences in the ways of reaching this number, as well as other reasons. However, according to the statistics available, the Soviet Union boasts the largest number, with 1.501 million (1986), followed by the United States with 802,000 (1986). These numbers are 3.6 and 1.9 times that of Japan, respectively. However, West Germany and France have fewer researchers than Japan. When comparing the number of researchers on a per 10,000 of population basis, Japan is on a par with the United States (Figure 2-1-20).

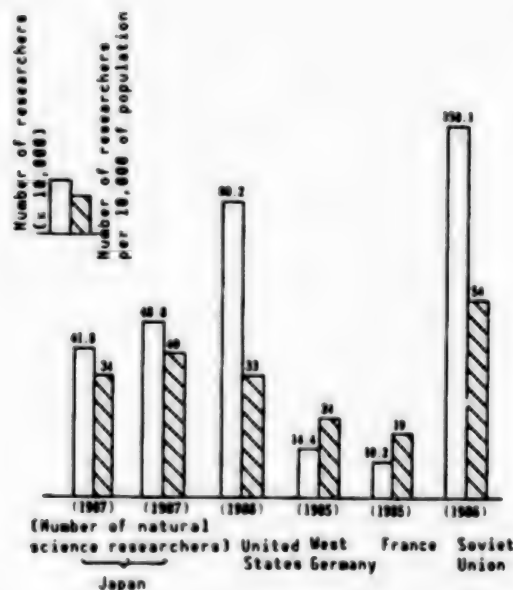


Figure 2-1-20. Numbers of Researchers in Major Countries

Notes: 1. Numbers of researchers for these countries combine researchers in social sciences and humanities. In the case of Japan, only the number of natural science researchers is given.

2. The U.S. figures are estimates.

Source: Refer to Figure 2-1-3. The populations are according to U.N. statistics.

(Number of people connected to research)

In 1987 the number of people connected to research in Japan stood at 692,000, an increase of 2.3 percent over the preceding year's 676,000 (Figure 2-1-21). The ratio of researchers to those connected to research and research-related businesses increased from 60 percent in 1986 to 60.5 percent in 1987. On the other hand, the ratio of research assistants declined from 14.6 percent to 14.4 percent, and the ratio of technical specialists from 14.9 percent to 14.7 percent, respectively. There was no change in the ratio of those in charge of business affairs and other research-related matters, at 10.5 percent.

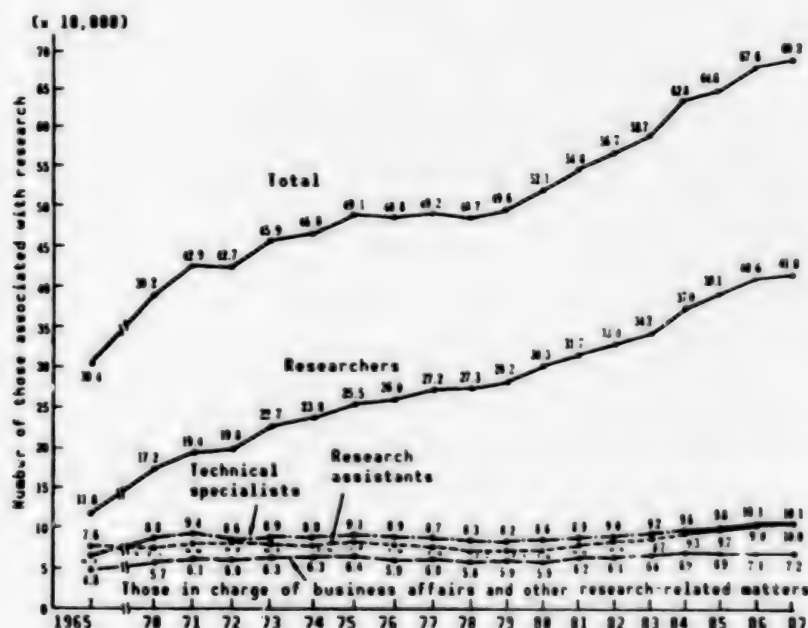


Figure 2-1-21. Shift in the Number of People Associated With Research

Note: Figures for each year as of 1 April

Source: "Report on S&T Research"

By category of research institution, the ratio of research assistants is generally higher at corporations, while at academic institutions the ratio of researchers is particularly high, at 7.9 percent in 1987 (Figure 2-1-22).

(Number of assistants per researcher)

The number of research assistants, technical specialists, clerical and other research-related people available to a researcher has been on the decline, with the number at 0.65 in 1987 (Figure 2-1-23).

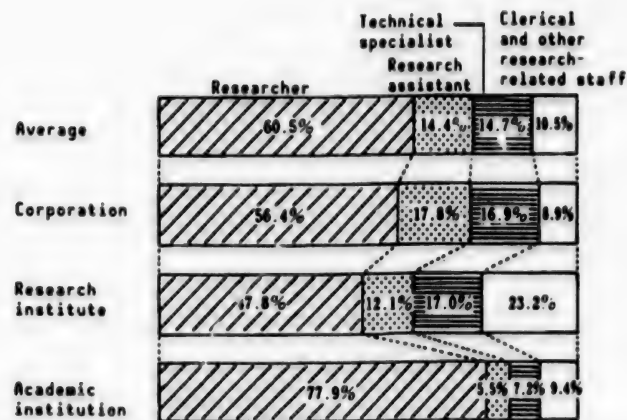


Figure 2-1-22. Percentages of Researchers and Other Research-Related People by Type of Institution

Note: As of 1 April 1987.

Source: "Report on S&T Research"

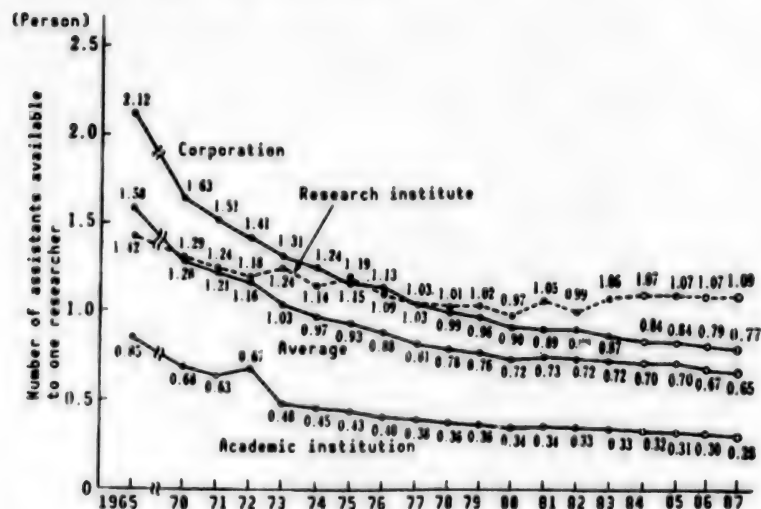


Figure 2-1-23. Shift in the Number of Assistants Available to a Researcher

Notes: 1. The figures represent the total of research assistants, technical specialists, clerical and other research-related people available to a researcher.

2. For each year as of 1 April.

Source: "Report on S&T Research"

2. Research Activities by Sector

(1) Research activities at corporations

(i) Research expenditures

The research expenditures by Japan's corporations in FY 1986 reached ¥6.1202 trillion, a gain of 3 percent over the preceding year, with the sum representing 72.7 percent of the total expenditures by Japan's researchers

during that year (Figure 2-1-5). Of this sum, 72.3 percent was used for the development of new products and new production methods, as well as toward the further improvement of existing technologies (Figure 2-1-12).

In FY 1986, 14,000 corporations (capitalized at higher than ¥5 million) were engaged in research activities, 89 percent of which were in the manufacturing sector, followed by those in the construction industry (9.9 percent). In the manufacturing industry, the machine industry accounted for the largest percentage, at 13.3 percent (Figure 2-1-24).

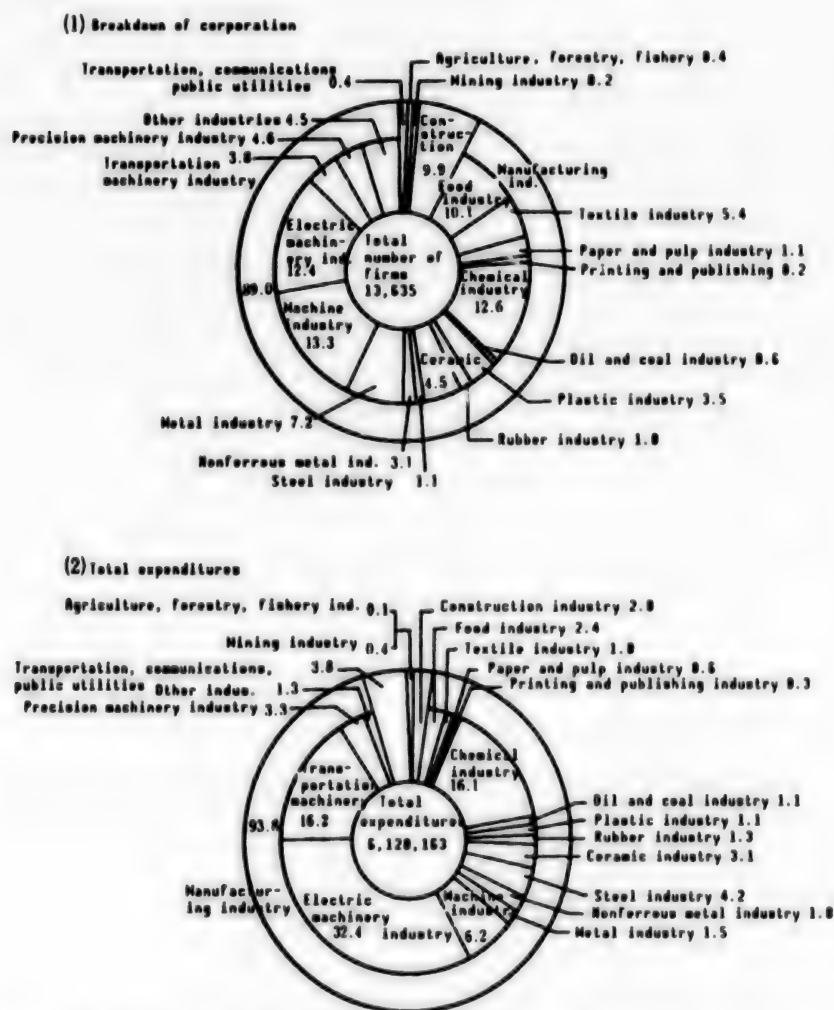


Figure 2-1-24. Breakdown of Companies Conducting Research, and Breakdown of the Total Research Expenditures by the Sector of Industry (FY 1986)

- Notes: 1. Companies covered were capitalized at higher than ¥5 million.
 2. Research money was for in-house use.
 3. The figures next to the names of industries represent the percentages of the total.

Source: "Report on S&T Research"

The manufacturing industry was the largest user of research money, spending 93.8 percent of it, followed by a group of transportation, communications and public utility industries at 3.8 percent. In the manufacturing industry, electric machinery was the largest user of the money, with a 32.4 percent share, followed by transportation machinery with 16.2 percent and the chemical industry with 16.1 percent. These three industries combined used 64.6 percent of the research money available in Japanese industry in FY 1986 (Figure 2-1-24). During the past 10 years (FY 1976-1986), the research expenditures in the electric machinery industry registered the largest growth among industries in Japan, with an average increase of 14.9 percent. It is followed by the transportation machinery industry with an increase of 13.2 percent and the chemical industry with a 10.8 percent increase.

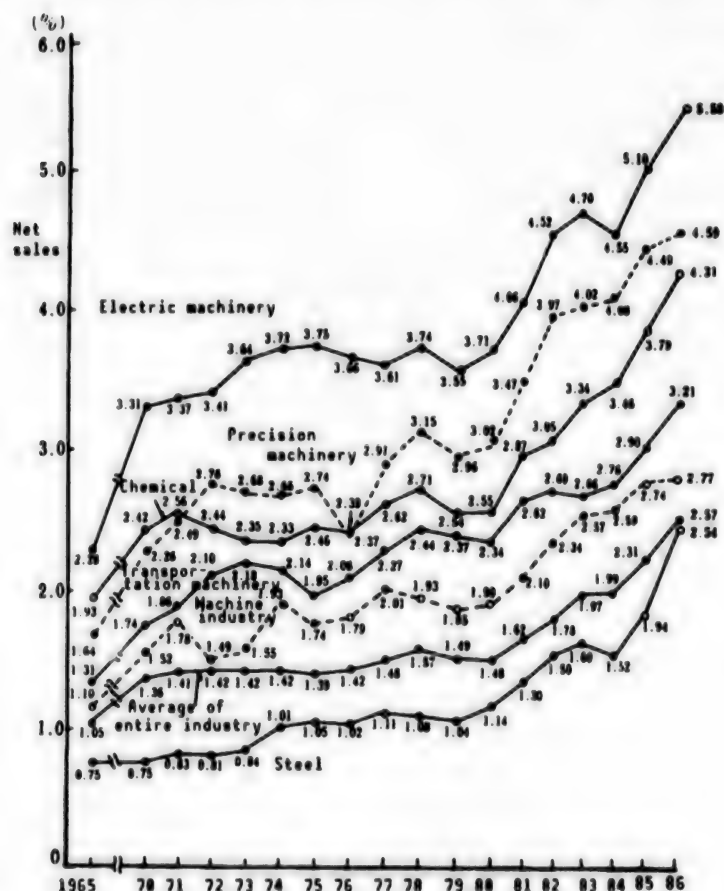


Figure 2-1-25. Shift in the Research Expenditures as Percent of Net Sales by Major Industries

- Notes: 1. Percentage of in-house research expenditures against net sales.
 2. The percentage figures are combined to those of ordinary corporations, while those of special corporations are not included.

Source: "Report on S&T Research"

The percentage of research expenditures against sales values is used to indicate the degree of a company's research activities. When the percentage is high, it means that the company recognizes the importance of research. In FY 1986, the average percentage of research expenditures in Japanese industry hit a record high of 2.57 percent. By industry, the electric machinery industry was the largest spender of research money, expending 5.5 percent of its net sales in FY 1986. It was followed by the precision machinery industry (4.59 percent), the chemical industry (4.31 percent) and the transportation machinery industry (3.21 percent) (Figure 2-1-25). As for the percentage of researchers' salaries in industrial research expenditures, it was on the increase beginning in 1970, reaching 51.9 percent in FY 1976. However, the percentage began to decline after FY 1977, and in FY 1986 it stood at 41.3 percent (Figure 2-1-26).

(FY)	Researcher's salaries	Material procure- ment costs	Cost for procurement of equipment and other fixed assets	Other expen- ditures	(Unit: %)
65	43.2	20.7	20.6	15.6	
70	39.7	20.3	21.9	18.2	
71	42.4	20.2	19.4	18.0	
72	45.3	19.5	17.4	17.8	
73	45.3	17.7	17.8	19.2	
74	50.2	17.6	18.9	18.2	
75	51.8	16.8	18.2	18.2	
76	51.9	17.5	17.6	19.0	
77	50.9	18.2	12.1	18.8	
78	49.8	19.0	12.5	18.8	
79	47.9	19.0	13.7	19.4	
80	46.2	18.7	15.1	20.1	
81	44.2	19.9	16.0	19.9	
82	43.3	19.8	15.9	20.9	
83	43.5	19.6	15.4	21.4	
84	42.1	20.5	15.5	22.0	
85	40.7	20.5	16.5	22.4	
86	41.3	20.5	15.7	22.5	

Figure 2-1-26. Shift in Research Expenditures of Corporations by Type of Cost

Source: "Report on S&T Research"

During the period from the latter half of the 1960s through the first half of the 1970s, the percentages of research expenditures in basic research and applied research declined consistently, while the percentage of development research continued to increase; in the latter half of the 1970s the decline and increase moderated substantially and remained relatively stable for several years; in the first half of the 1980s the percentages of basic research and applied research began to increase gradually; and in FY 1986 the percentage of research expenditures in basic research stood at 6.1 percent, applied research at 21.6 percent and development research at 72.3 percent (Figure 2-1-27).

(FY)	Basic research	Applied research	Development research	(Unit: %)
1965	11.2	31.3	57.5	
70	9.3	27.2	63.5	
71	9.1	25.9	65.0	
72	8.1	22.3	69.6	
73	6.7	19.5	73.8	
74	6.3	19.4	74.3	
75	5.2	19.1	75.8	
76	5.0	18.6	76.3	
77	4.7	19.6	75.7	
78	4.6	18.2	77.1	
79	4.6	19.5	75.9	
80	5.0	19.5	75.5	
81	5.2	21.8	73.0	
82	5.5	21.9	72.6	
83	5.7	22.0	72.3	
84	5.6	22.0	72.4	
85	5.9	21.9	72.1	
86	6.1	21.6	72.3	

Figure 2-1-27. Shift in the Amount of Research Expenditures in the Character of Research by Corporations

Source: "Report on S&T Research"

On the other hand, the average amount of research expenditures per researcher at corporations in FY 1986 stood at ¥24.31 million, a decline of 5.4 percent from the preceding year. By industry, the group consisting of transportation communications and public utilities industries led other domestic industries with ¥43.78 million, followed by the mining industry with ¥31.03 million, the manufacturing industry with ¥23.94 million, the agriculture, forestry and fisheries industry with ¥22.050 million and the construction industry with ¥21.05 million. In the manufacturing industry, the steel industry outdistanced others with ¥47.23 million, followed by the transportation machinery industry with ¥41.43 million and the oil and coal industry with ¥35.83 million (Figure 2-1-29).

(ii) Researchers at corporations

As of 1 April 1987, the number of researchers at corporations in Japan totaled 261,000, an increase of 3.6 percent over the 252,000 of the preceding year. By industry, the manufacturing industry had 248,000 researchers, accounting for 95.2 percent of the industry. In the manufacturing industry,

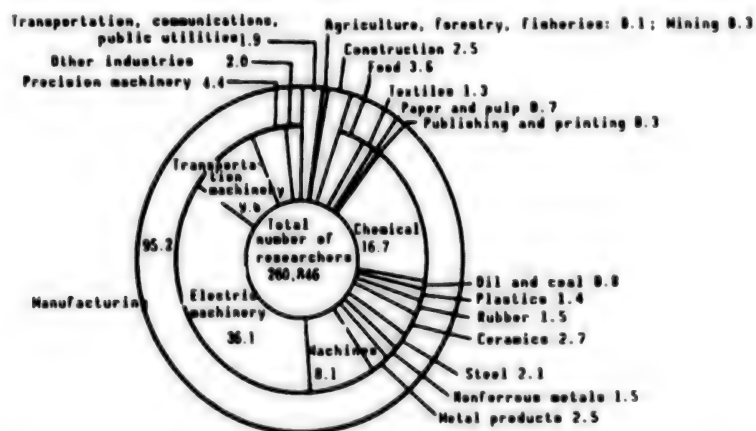


Figure 2-1-28. Percentages of Researchers by Industry (1987)

Notes: 1. Corporations covered were capitalized at higher than ¥5 million.

2. As of 1 April 1987.

3. The percentages represent the share of each industry in the total number of researchers.

Source: "Report on S&T Research"

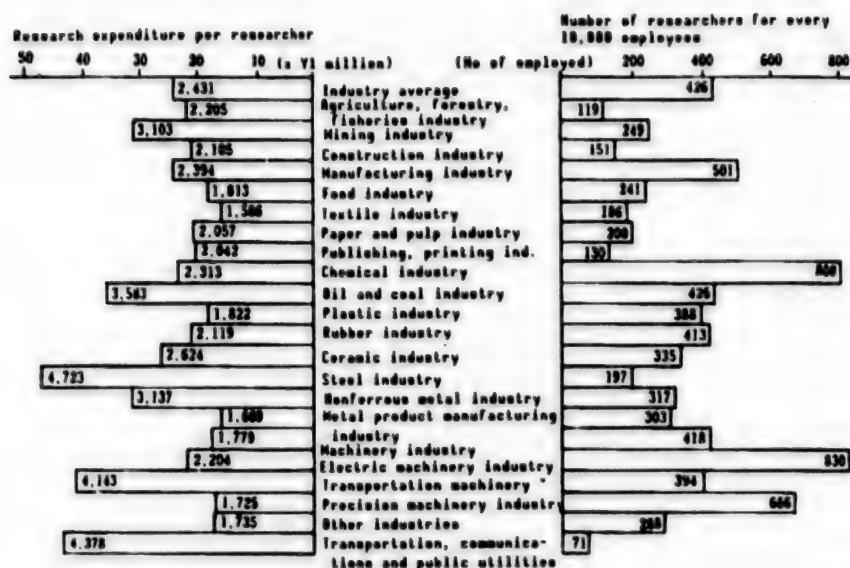


Figure 2-1-29. Research Expenditures Per Researcher by Corporations and the Number of Researchers for Every 10,000 Employees

- Notes: 1. The number of researchers as of 1 April 1986, and the 1986 data are used for research expenditures per researcher.
 2. The number of researchers for every 10,000 employees as of 1 April 1987.

Source: "Report on S&T Research"

the electric machinery industry had 94,000 researchers (36.1 percent of all industries), followed by the chemical industry with 44,000 (16.7 percent). These two industries combined accounted for half of the number of researchers in Japanese industries (Figure 2-1-28). As for the number of researchers per 10,000 employees, the manufacturing industry had 501 researchers, far surpassing the industry-wide average of 426. In the manufacturing industry, the chemical industry had 808 researchers, electric machinery industry 830, precision machinery industry 666, machine industry 418, and oil and coal industry 426 researchers (Figure 2-1-29).

By field of specialty, 60.9 percent was engineering researchers, 27.1 percent scientists, 3.3 percent agricultural researchers and 3.1 percent health specialists. In the engineering field, many researchers were engaged in research in electronics/communications fields and machinery/shipbuilding/aviation fields; while in the physical science field, the largest number of researchers was involved in research in the chemical field. The researchers in these three major fields combined accounted for about three-fourths of all researchers in Japan's corporations in 1987 (Figure 2-1-30).

(2) Research activities at research institutes

Research institutes are engaged mainly in basic and large-scale pioneering research, including nuclear development and space development, as well as in research related to national policies, such as securing a stable supply of food and energy, in research whose results will be beneficial to small-to-

medium-sized enterprises which do not have the resources necessary to pursue research on their own, and in research in industrial fields which sustain the local economy. It is difficult for private sector corporations to pursue research in these fields for various reasons, and in many cases these research institutes are supported financially by the central and local governments.

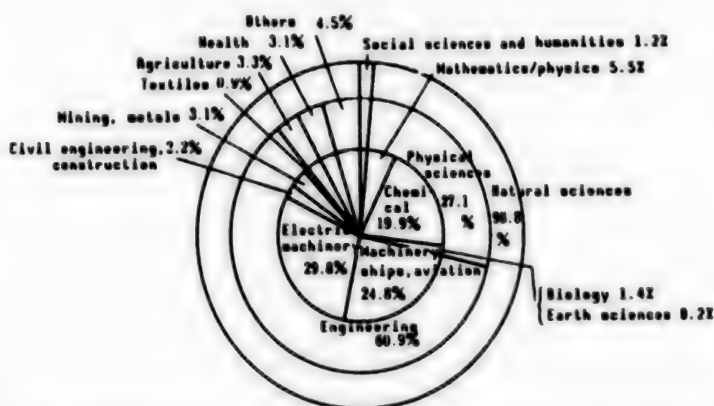


Figure 2-1-30. Percentages of Researchers by Field of Specialty in Japanese Corporations

Note: As of 1 April 1987

Source: "Report on S&T Research"

(1) Research expenditures at research institutes

In FY 1986, the research expenditures at research institutes in Japan stood at ¥1.173 trillion, accounting for 13.9 percent of the total research expenditures in Japan that year and a gain of 6.5 percent over the preceding year (Figure 2-1-5).

During that year, the government shouldered most of the research expenditures at the government-run research institutes and the special corporations, and 22.6 percent of the expenditures at private sector institutions. This means that, of the total research expenditures at the research institutes, the government shouldered 72 percent of the expenditures while the private sector covered 27.8 percent.

As for the number of research institutes which were engaged in research and development activities in FY 1986, there were decreases of one institution each at the national institutions and special corporation categories, and of nine establishments at other public institutions. In contrast, there was an increase of 39 new research institutes in the private sector. As a result, the ratio of those research establishments in FY 1986 can be broken down to 8.5 percent national, 54.3 percent public, 0.6 percent special and 36.5 percent private sector. By field of specialty, they break down to 9.8 percent physical sciences, 36.5 percent engineering, 42 percent agriculture and 11.8 percent public health (Figure 2-1-31).

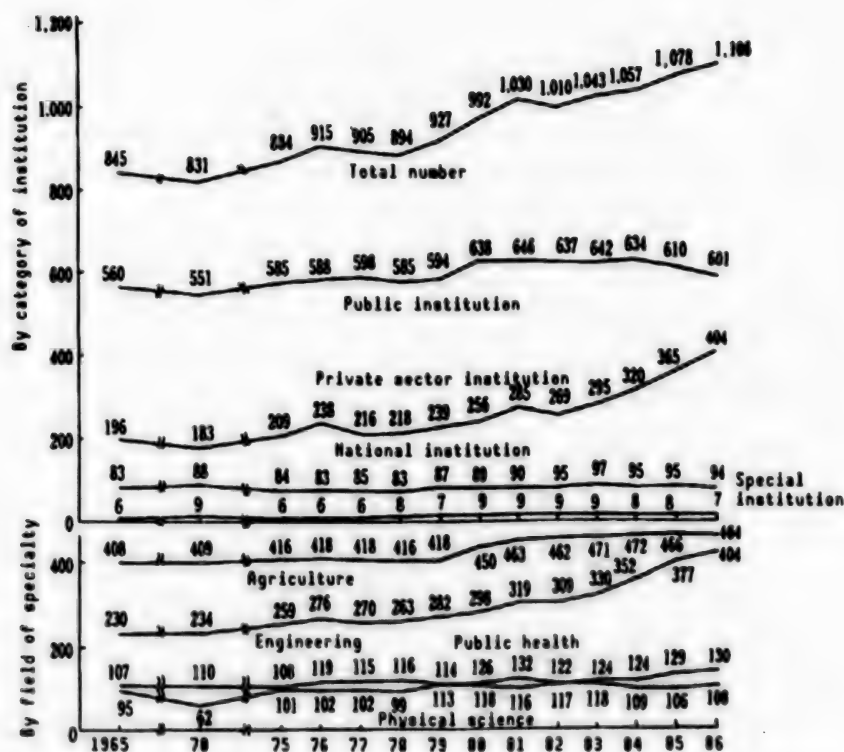


Figure 2-1-31. Shift in Number of Research Institutes by Category and by Field of Specialty

Note: For the 1965 and 1970 in the "field of specialty" section, there are 5 and 16 research institutes, both classified as "others," respectively.

Source: "Report on S&T Research"

Among national institutions, engineering institutions accounted for 40.4 percent and agricultural institutions 29.8 percent; among public institutions agricultural institutions represented 60.6 percent followed by engineering institutions at 22.5 percent; in the private sector, engineering institutions came to the top with 56.7 percent followed by agricultural institutions at 17.8 percent; and most special corporations specialized in either physical sciences or engineering.

In FY 1986, research expenditures at national research institutes stood at ¥236.7 billion, at public research institutes at ¥193.6 billion, at private sector institutions at ¥360.4 billion and at special corporations at ¥382.3 billion, accounting for 20.2 percent, 16.5 percent, 30.7 percent and 32.6 percent, respectively, of the total research expenditures during that year (Figure 2-1-32).

By field of specialty, the percentage of engineering was the highest with 49.1 percent, followed by sciences (29.2 percent), agriculture (15.8 percent) and public health (5.9 percent) (Figure 2-1-33).

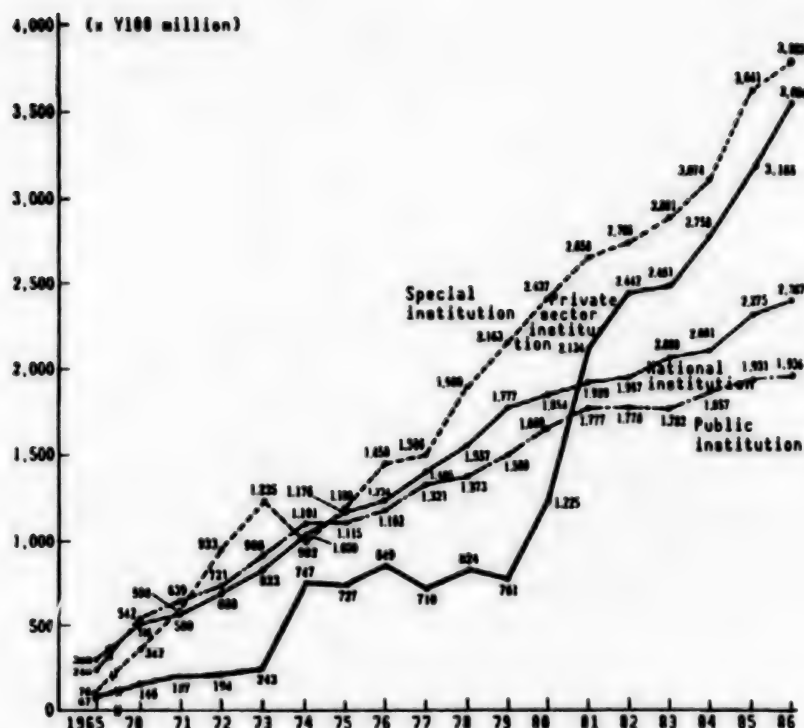


Figure 2-1-32. Shift in the Amounts of Research Expenditures at Japanese Research Institutes

Note: The reason for the dip in research expenditures in special corporations and the sharp growth in research expenditures in the private sector in FY 1974 is a result of the reclassification of the Technical Research Union, an entity established under the mining industry technology research law, from the category of special corporation to that of private sector corporation.

Source: "Report on S&T Research"

At public research institutes, the salaries paid to the researchers occupy a very large portion of the research expenditures, while at special corporations, the ratio of expenditures for the procurement of fixed assets is unusually high since their research in the fields of nuclear development and space development requires large-scale facilities and costly equipment (Figure 2-1-34).

On the other hand, at national research institutes the ratio of expenditures related to basic research is larger than at any other research institute, at public research institutions the expenditures for applied research are larger, and at special corporations the ratio of expenditures for development research is unusually high compared to that of other institutions. At public health research institutes emphasis is placed on basic and applied research, while at agricultural research institutes emphasis is placed on applied research, and at engineering and physical science research institutes the weight of development research is high (Figure 2-1-35).

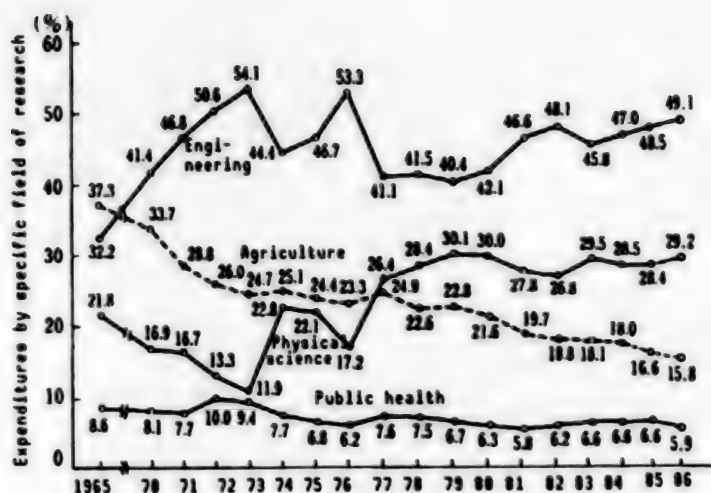


Figure 2-1-33. Shift in the Amount of Research Expenditures at Research Institutes by Field of Research

Note: Before 1974, there were fiscal years in which the item of public health included natural science field research expenditures, excluding the fields of engineering, agriculture, physical science and public health, with the amount of the expenditures less than 1 percent of the total expended.

Source: "Report on S&T Research"

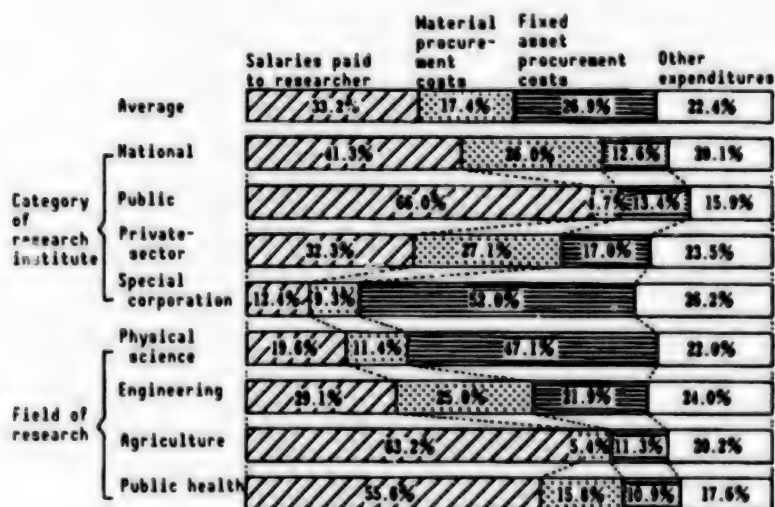


Figure 2-1-34. Research Expenditures by Type of Cost at Research Institutes (FY 1986)

Source: "Report on S&T Research"

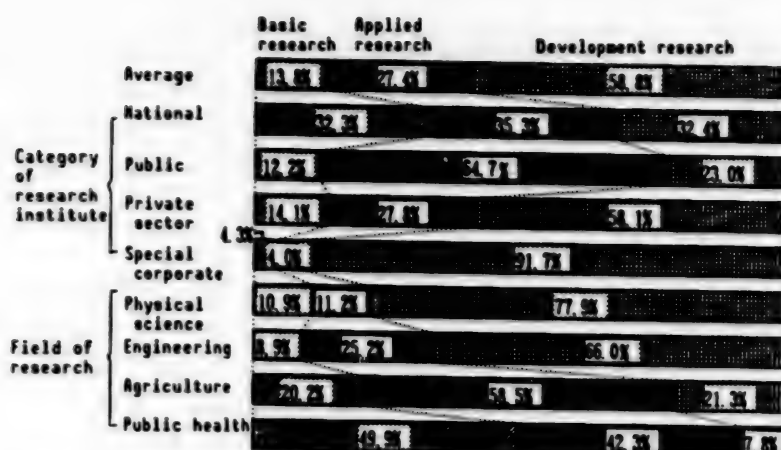


Figure 2-1-35. Ratios of Research Expenditures by Nature of Research at Research Institutes (FY 1986)

Source: "Report on S&T Research"

[In FY 1986], the research expenditures per researcher in Japan's research institutes averaged ¥36.14 million, a gain of 5.6 percent over the preceding year. By research sector category, special corporations rose to the top in amount of per-researcher expenditures with ¥150.2 million, followed by private sector institutions with ¥61.07 million, national research institutes with ¥23.28 million and public institutions with ¥13.98 million.

(11) Research-related staff at research institutes

The number of researchers at Japan's research institutes as of 1 April 1987, totaled 33,000, a gain of 2.5 percent over the preceding year.

By category of research sector, the number of researchers at research institutes stood at 10,000 (30.4 percent of the total), a decline of 0.6 percent from the preceding year; at public institutions it stood at 14,000 (41.3 percent), a loss of 0.7 percent; at private sector institutions 7,000 (20.2 percent), a gain of 13.8 percent; and at special corporations 3,000 (8.1 percent), an increase of 5.6 percent. The national and public institutions combined accounted for 71.7 percent of the total (Figure 2-1-36).

By field of research, engineering controlled 39.1 percent of the total, followed by agriculture with 33.7 percent, physical sciences with 16.2 percent and public health with 11 percent (Table 2-1-37).

In 1987, the number of those associated with research in Japan totaled 70,000. This breaks down to 33,000 researchers (47.8 percent of the total), 8,000 research assistants (12.1 percent), 12,000 technical specialists (17 percent) and 16,000 others (23.2 percent) who were in charge of clerical and other research-related tasks. By category of research institute, the ratio of researchers was high at national and public institutions, while at private sector institutions and special corporations the ratio of research assistants was high (Figure 2-1-38).

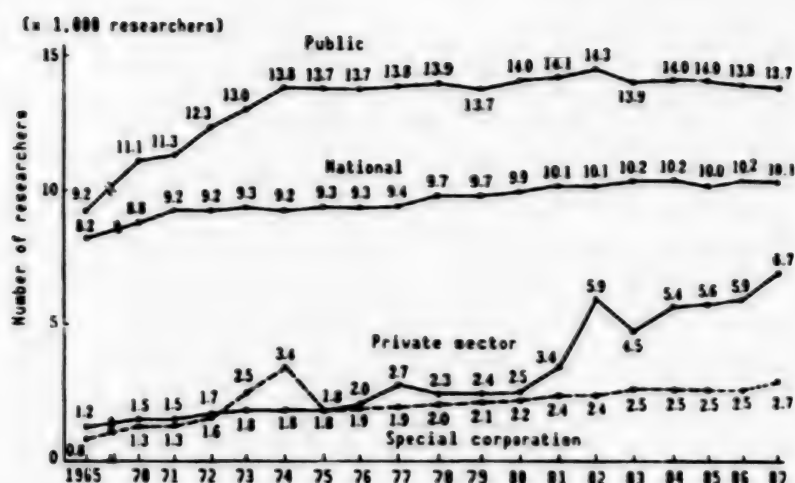


Figure 2-1-36. Shift in Number of Researchers at Research Institutes by Category of Research Sector

Note: As of 1 April for each year.

Source: "Report on S&T Research"

Table 2-1-37. Number of Researchers at Research Institutes by Field of Research and by Category of Research Sector (FY 1987)

Research field Research sector	Total number	Physical sciences	Engi- neering	Agricul- ture	Public Health
Total number (%)	33,257 (100.0)	5,373 (16.2)	13,003 (39.1)	11,213 (33.7)	3,668 (11.0)
National institution	10,106	1,338	4,525	3,125	1,118
Public institution	13,748	1,254	3,374	7,478	1,642
Private institution	6,715	558	4,639	610	908
Special corporation	2,688	2,223	465	--	--

Note: As of 1 April 1987

Source: "Report on S&T Research"

(3) Research activities at academic institutions

As institutions of higher learning, universities are producing researchers while, at the same time, playing an important role as research institutes, particularly in the field of basic research for the development of new technologies. Universities are engaged in a wide field of research.

There were 708 universities in FY 1986 in the field of natural science, an increase of 1.9 percent over the preceding year. By category of university, national universities accounted for 55.2 percent, public universities 7.5 percent and private universities 37.3 percent, respectively (Figure 2-1-39).

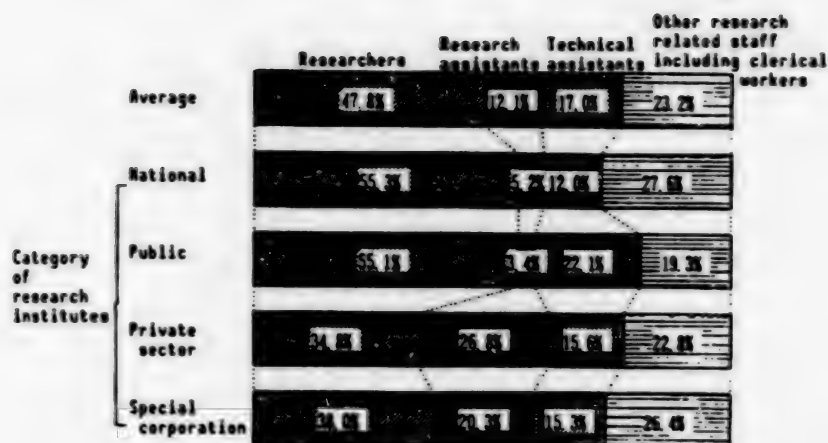


Figure 2-1-38. Numbers of Research-Related Staff at Japan's Research Institutes by Category of Research Institution

Note: As of 1 April 1987.

Source: "Report on S&T Research"



Figure 2-1-39. Shift in the Number of Universities by Sector and Field

Notes: 1. Faculty is the basic unit in counting the number of universities

2. As of 1 April each year.

Source: "Report on S&T Research"

(1) Research expenditures at universities

In FY 1986, research expenditures by universities in Japan totaled ¥1.1219 trillion, an increase of 4.3 percent over the preceding year (Figure 2-1-5).

By category of university, national universities had expenditures of ¥610.8 billion, public universities ¥57.5 billion and private universities ¥453.5 billion, accounting for 54.4, 5.1 and 40.4 percent, respectively, of the total. In comparison with the preceding year, these expenditure figures represented increases of 3.7, 2.2 and 5.5 percent, respectively (Figure 2-1-40).

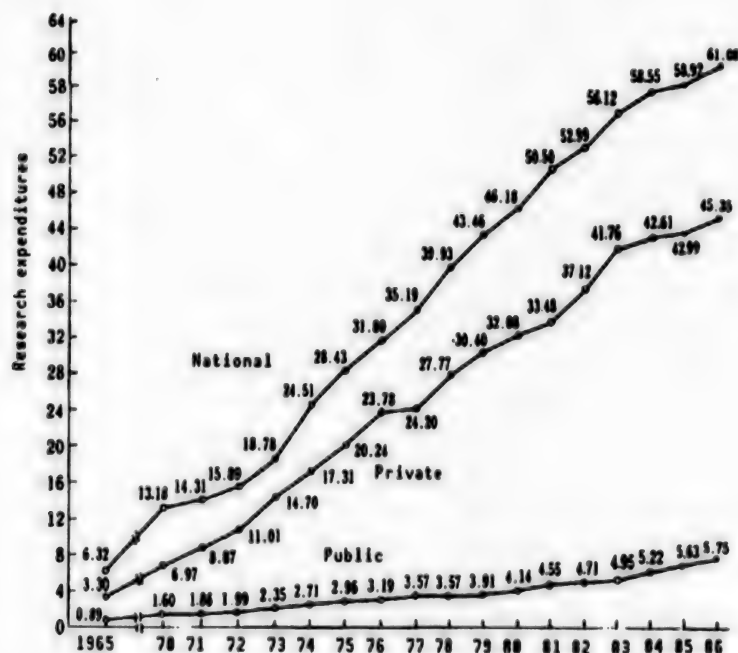


Figure 2-1-40. Shift in the Amount of Research Expenditures by Universities
Source: "Report on S&T Research"

By field of research, expenditures in physical sciences stood at ¥163.4 billion, engineering at ¥393.1 billion, agriculture at ¥88 billion and public health at ¥477.4 billion, accounting for 14.6, 35, 7.8 and 42.6 percent of the total, respectively. Engineering and public health combined used about 80 percent of the total expenditures.

Compared with the situation at corporations and research institutes, the percentage of researchers' salaries in the research expenditures is larger at academic institutions. In FY 1986, this percentage stood at 61 percent, reaching as high as 78.6 percent at public universities. By field of research, the percentage of researchers' salaries was particularly high in engineering, agriculture and public health. In the field of physical

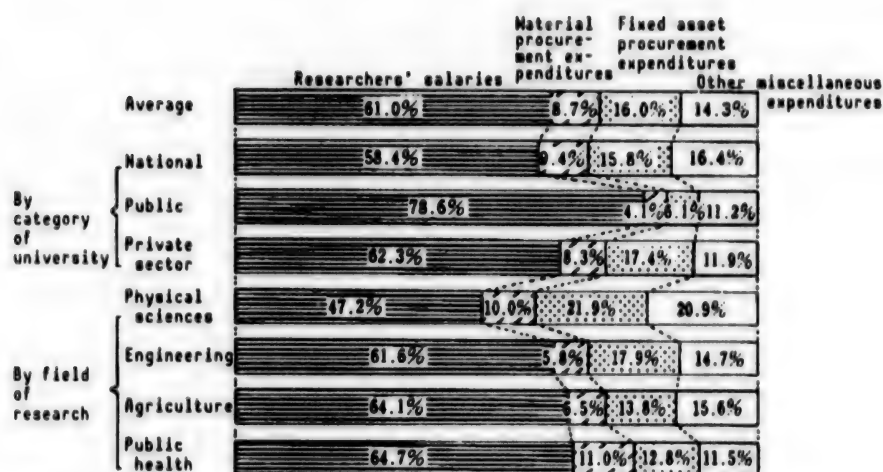


Figure 2-1-41. Research Expenditures of Universities by Type of Cost (1986)
Source: "Report on S&T Research"

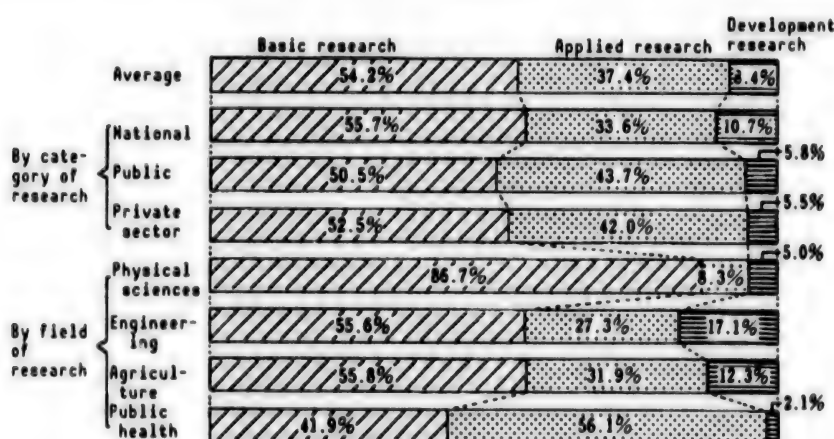


Figure 2-1-42. Research Expenditures of Universities by Character of Research (FY 1986)
Source: "Report on S&T Research"

sciences, the percentage expended to procure fixed research-related assets was conspicuously high (Figure 2-1-41). By the nature of research, expenditures in basic research were the highest, accounting for 54.2 percent of the total expenditure value in FY 1986, while expenditures in development research were far smaller (Figure 2-1-42).

Per-researcher expenditures [in FY 1986] at universities increased from the ¥9.11 million of the previous year to ¥9.25 million, a gain of 1.5 percent. When the term "researcher" is confined to the teachers who play the central role in research, per-researcher expenditures go up to ¥14.55 million on the national average. By category of university, per-researcher expenditures at national universities stood at ¥15.37 million, at public universities at ¥11.39 million and at private universities at ¥14.03 million.

(ii) Research-related staff at universities

As of 1 April 1987, the number of researchers at Japan's universities totaled 124,000, an increase of 2.4 percent over the previous year. By the category of university, national universities had an annual increase of 2.5 percent, public universities a gain of 3 percent and private universities a growth of 2.1 percent, respectively (Figure 2-1-43).

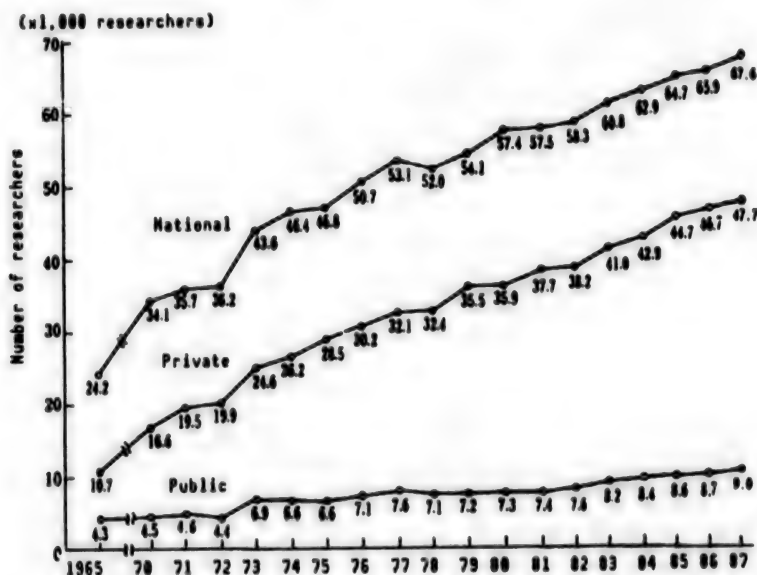


Figure 2-1-43. Shift in Number of Researchers at Universities

Notes: 1. As of 1 April each year.

2. The reason for the marked increase in the number in 1973 is due to the inclusion of interns and other non-full-fledged researchers in the count for that year.

Source: "Report on S&T Research"

In 1987, the number of research-related people at Japan's universities totaled 160,000. Of that total, there were 124,000 researchers, or 77.9 percent of the total, 9,000 research assistants (5.5 percent), 12,000 technical specialists (7.2 percent) and 15,000 clerical and other research-related staff was 15,000 (9.4 percent) (Figure 2-1-44).

Researchers can be classified into teachers, doctorate-course postgraduate students, interns and other non-full-fledged researchers. At national universities, the percentage of postgraduate students was particularly high, at public universities the number of interns and other non-full-fledged researchers is high, and at private universities the percentage of teachers is high and that of postgraduate school students is low (Figure 2-1-45).

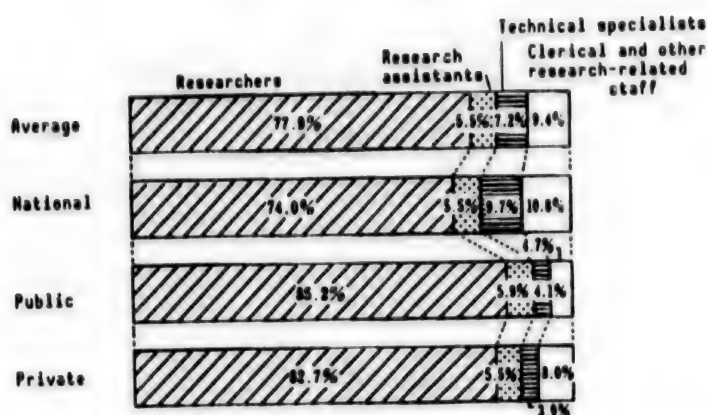


Figure 2-1-44. Breakdown of the Number of Research-Related Staff at Universities

Note: As of 1 April 1987

Source: "Report on S&T Research"

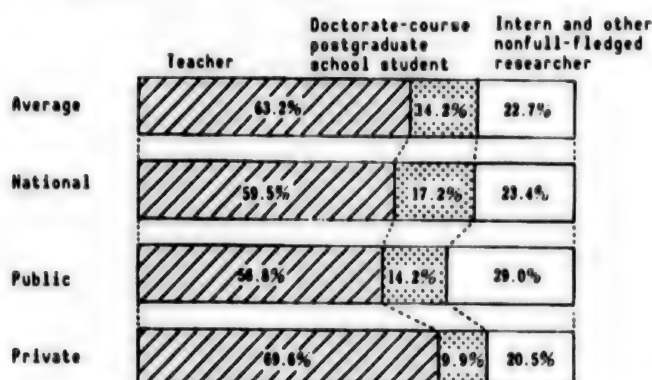


Figure 2-1-45. Breakdown of the Number of Research-Related Staff at Universities

Note: As of 1 April 1987.

Source: "Report on S&T Research"

Part 2. Trends in Science and Technology Information Activity

Much of the knowledge and experience acquired during scientific research, development, investigation and other science-related activities have been publicized as new information in the form of characters, graphics, images and sound. Such information constitutes the fruit of scientific and technological research and development activities by many able researchers by spending a huge amount of money, and, in this sense, the information must be used to help promote additional new R&D programs. With the notable progress in the field of science and technology in recent years, the volume of information generated has been steadily increasing. It is estimated that the number of publicized information items (articles in S&T magazines, patents, technical reports, theses for a degree, conference materials, etc.) in the world surpasses 6 million items per year. This "flood of information" makes the speedy retrieval of a needed piece of information difficult today.

This situation makes it imperative that a system be established that will enable information to be presented, which will meet the needs of individual customers, by processing collected information into a more appropriate form so that it can be accessed at a faster speed. The remarkable progress in computer and data communications technologies in the recent past has encouraged data base building efforts in both the public and private sectors in many countries, and in those countries an increasing number of newcomers are hopping on the bandwagon of data base service.

This paper will refer to the recent information-related activities in science and technology fields, and touch on the policies taken by Japan and other countries to promote these activities.

1. Recent Situation in S&T Information Fields

(1) Swelling data bases

An increase in the volume of information calls for an increase in the time and number of staff required to collect it and process it into an appropriate form. To perform the processing speedily and accurately, many information-handling establishments are currently using computers. In recent years, the volume of S&T information generated has increased markedly worldwide, and the information is being actively utilized by various customers. In the fields of science and technology, most of the data bases now available are nonnumerical ones, however, the importance of "fact data bases," based on numerical data, is also increasing.

(2) Progress in on-line information services

In the fields of science and technology, a significant portion of information retrieval services is currently being operated on-line. The advantages of providing information services on-line are: ease with which the question formula can be modified through dialogue with the computer system; the capability to immediately obtain needed information from remotely-located data bases, and relative ease by which the information retrieval system can be used as long as the strictness required when searching an information item is minimal. Due to these advantages, the demand for on-line information services are expected to continue to grow in the future. In anticipation of this, the on-line information service establishments in major countries have been introducing large-capacity host computers to beef up the contents of the data bases and are vying to increase their customers by improving the accessibility and cutting service rates.

Turning to the domestic situation in Japan, there are currently a number of companies and other establishments which are offering on-line information services, and the service network is expanding. As for the communications lines used to provide the service, the DX and VENUS-P are used as domestic and international service networks, in addition to the conventional public telephone lines. Ever since the domestic telecommunications service was deregulated in April 1985, the domestic communications service has been diversifying, with many new so-called VAN operators entering the market.

(3) International distribution of S&T information

The high level of science and technology in Japan has caused the demand for Japanese S&T information from foreign countries to increase sharply in recent years. To meet this demand and promote the international distribution of Japanese S&T information, in November 1987 an international S&T information network, STN International, was established as a result of a tripartite agreement among the Japan Information Center for Science and Technology (JICST), Chemical Abstracts Service (CAS) in the United States and FIZ-Karlsruhe in West Germany. The network is already being operated. In addition to this, the JICST is expanding its English data base and is developing a computer translation system to translate domestic scientific and technical materials into English.

(4) Growing expectations for value-added information service

The computer processing of collected information has made searching for needed information easier and faster. Under these circumstances, the demand for higher value-added information services using existing data bases, including proxy information searches, surveys of technical developments and consulting services involving the analysis/evaluation of information, is growing for information not only in the area of research and development, but also in planning, management and technical transfer.

2. S&T Information-Related Activities in Japan

(1) Collection, processing and provision of information

In Japan various services related to S&T information are being offered by many establishments, including the general as well as the specialized-field centers of the "national distribution system of S&T information (NIST)." Table 2-2-1 gives the activities of the major information service establishments. In addition to those included in the table, there are many private sector companies which have begun to offer information services in recent years.

Table 2-2-1. Major S&T Information Service Establishments in Japan (confined to governmental, semigovernmental and other public establishments)

Field	Name of establishment	Activity
Science and technology in general	JICST	<ul style="list-style-type: none"> • Functions as the NIST national center • Gathers basic information in S&T fields and processes and offers it • Introduces research themes by national and public research institutes and by certain private sector research institutes • Operates STN-International • Has created and offers a fact data base (dictionary of chemical compounds in Japanese, mass spectrum, thermal property data, etc.)
	Science Information Center	<ul style="list-style-type: none"> • Coordinates the flow of information among national universities • Gathers, processes and offers science information and develops science information-handling systems • Offers a data base on publication information research subsidies and research results
Patent	Japan Patent Information Corporation	<ul style="list-style-type: none"> • Documents patents and designs of practical utility and offers information on the technical details of those patents and designs • Offers information on documented U.S. patents • Publishes abstracts of patent information in Japanese • Exchanges international patent data with the International Patent Information Center (INPADOC)
Agriculture, forestry and fisheries	Agriculture, Forestry and Fisheries Fisheries Research Information Center	<ul style="list-style-type: none"> • Gathers domestic and international information about agriculture, forestry and fisheries, and processes and offers it • Publishes a list of the publications on agriculture, forestry and fisheries • Has improved the computerized search system (RECRAS II) for research themes at national and public institutions in the fields of agriculture, forestry and fisheries

[continued]

[Continuation of Table 2-2-1]

Field	Name of establishment	Activity
[continuation]		<ul style="list-style-type: none"> • Inputs data to the U.N. Food and Agricultural Organization's International Information System on Agronomy and Agriculture Technology (AGIS), and offers the data files
	Agriculture, Forestry and Fisheries Technical Information Association	Copies materials on agriculture, forestry and fisheries and offers references to them
Food	Food Industry Center	<ul style="list-style-type: none"> • Gathers information about food industry-related technology and updates it • Offers information via JICST • Publishes periodicals
Medicine and pharmacy	International Medical Information Center	<ul style="list-style-type: none"> • Gathers and offers domestic and international medical information • Offers medical and biological information from the information to be inputted to International Nuclear Information System (INIS)
	Japan Pharmaceutical Information Center	<ul style="list-style-type: none"> • Gathers domestic and international medicine-related materials and the documents attached to medicines produced in Japan, processes them, and offers the processed information
	Igaku Chuo Zasshi Kankokai	<ul style="list-style-type: none"> • Publishes a medical journal covering medical conference documents and the articles appearing in medical journals published in Japan • Has created a data base for the publication, and offers the data base on-line via JICST
Medical care	Welfare Statistics Association Toxicant Information Center	<ul style="list-style-type: none"> • Publishes publications on demographic statistics and hygiene statistics • Gathers and offers information about acute poisoning caused by chemical substances
Life science (living things used in experiments)	Institute of Physical and Chemical Research	<ul style="list-style-type: none"> • Gathers and updates information about guinea pigs, microorganisms, algae and the cultivation of animal/plant cells

[continued]

[Continuation of Table 2-2-1]

Field	Name of establishment	Activity
Chemistry	Chemical Information Association	<ul style="list-style-type: none"> • Publishes a quick report on domestic chemical information • Cooperates with Chemical Abstracts Service (CAS) of the United States • Offers spectrum data base
	Basic Technology Research Promotion Center Japan Chemical Substance Safety Information Center	<ul style="list-style-type: none"> • Gathers, processes and offers domestic and international information about the safety of chemical substances • Has created a data base of the rules governing chemical substances (with cooperation of JICST) • Has created a data base of the chemical substances governed by a law requiring mandatory notification.
Metal	Japan Steel Association (Steel Technology Information Center)	<ul style="list-style-type: none"> • Gathers and updates information about steel and other metals • Cooperates with JICST by inputting data to JICST files • Engages in international cooperation
Work place accidents	Central Work Place Accident Prevention Association	<ul style="list-style-type: none"> • Gathers and updates information about work place safety and hygiene • Offers information to the Center for International Safety (CIS)
Environmental pollution	Environment Agency's National Institute for Environment Studies	<ul style="list-style-type: none"> • Gathers and updates information about environmental pollution reports, pollution data and the sources of information at the Environment Condition Information Department • Serves as the center of the International Environmental Information Reference System (INFOTERRA)
Disaster prevention	Science and Technology Agency's National Research Center for Disaster Prevention, Tokyo University's Earthquake Research Institute (Earthquake Prediction and Observation Center)	<ul style="list-style-type: none"> • Gathers and updates materials related to disaster prevention technology • Gathers data about strong earthquakes • Gathers, processes and offers data about minor quakes

[continued]

[Continuation of Table 2-2-1]

Field	Name of establishment	Activity
Nuclear energy	Japan Atomic Energy Research Institute	<ul style="list-style-type: none"> • Gathers and updates information about nuclear energy at the Technical Information Department • Inputs nuclear-related information involving Japan to the International Atomic Energy Agency's International Nuclear Information System (INIS), and offers it to domestic customers
	New Energy Development Organization	<ul style="list-style-type: none"> • Offers the IEA energy technology data base under an agreement with IEA
Meteorological field	Japan Meteorological Association	<ul style="list-style-type: none"> • Offers meteorological information
Marine field	Marine Science and Technology Center	<ul style="list-style-type: none"> • Offers information about marine science and technology
	Marine Resource Development Center	<ul style="list-style-type: none"> • Gathers and offers information concerning the development of marine resources
	Japan Marine Data Center (Maritime Safety Agency's Hydrographic Dept.)	<ul style="list-style-type: none"> • Gathers, manages and offers sea information and data • Exchanges marine data under the international marine data conversion system of the UNESCO-Intergovernmental Oceanographic Committee (IOC)
Shipping	Japan Shipbuilding Promotion Association	<ul style="list-style-type: none"> • Gathers technical materials about ships and marine engineering from around the world, publishes the abstracts and offers domestic technical documents to foreign countries by translating them into English
Small enterprises	Small Business Corp. (Small Business Information Center)	<ul style="list-style-type: none"> • Offers technological, management, and guidance information to small businesses
Construction	Japan Construction Information Center	<ul style="list-style-type: none"> • Has created data base of construction technology and offers related information services • Publishes documents containing information about construction technology

Note: New Energy Development Organization was renamed New Energy and Industrial Technology Development Organization in October 1988.

(2) Factual information activities

Various research and observation institutions are creating data bases of the data they obtain through tests, measurements and observations. Table 2-2-2 shows these data bases classified by field of research. Some of these data bases have accumulated substantial amounts of data and, except for a few instances, their utilization is confined mostly to academic research and certain government businesses.

Table 2-2-2. Numbers of Fact Data Bases by Field of Science

Field of science	Number of data bases
Life sciences	17
Medicine, pharmacology	4
Chemistry	21
Material	19
Resources, energy	5
Environmental engineering	3
Construction, civil engineering	5
Oceanography	2
Geophysics	9
Nuclear engineering, nuclear chemistry	9
Machine engineering	2
Information engineering	2
Astronomy	1
Hydraulic engineering	1
Total	100

Source: Report on the results of a 1986 survey on "research investigation of fact data bases," funded by the Science and Technology Agency

(3) Original material information service

The service of perusal, copying and lending of original S&T materials is being offered by many establishments, including the National Diet Library, university libraries, public libraries, specialized-field libraries and many of the information service establishments listed in Table 2-2-1.

In Japan, when new books, magazines or other publications are published, the publisher is required to present a copy to the National Diet Library, and the library, by classifying and indexing them, offers on-line information on the publications received and retained. In addition, the library publishes a weekly report of the publications received.

At the Ministry of Education, the Science Information Center creates a data base listing the science-related publications held by university libraries and the libraries of major domestic research institutions with their cooperation, and offers the data base service. The center also publishes a list of those publications.

(4) Information analysis and other services

To analyze researched information and add a further value to it at the request of the customer requires knowledge in highly specialized fields. There are currently many information service establishments which offer such value-added services. However, it can hardly be said that the services offered by these establishments completely satisfy the diverse needs of the customers. The private sector think tanks and proxy information search service companies are increasingly looking toward offering value-added services. On the other hand, the Small Business Corp. (Small business Information Center) and regional information centers for small-and-medium-sized enterprises are already offering technology and management information designed to help the operators of these companies.

On the other hand, JICST offers an on-line service to provide information about the themes of various research projects conducted at domestic public research institutes. In addition, the Science Information Center has created a data base of report summaries of the results of research subsidized by the Ministry of Education and offers it on-line.

(5) International cooperation

As for the science and technology-related activities at such international arenas as the United Nations and the conference of the International Academic Federation, Japan has been contributing either at the governmental or private level when required. Bilateral cooperation is being promoted in the governmental level between Japan and the United States and between Japan and West Germany in the field of science and technology information exchange.

Cooperation between Japan and the United States is being promoted as part of a bilateral cooperation project in the sciences under the supervision of the Japan-U.S. committee on cooperation by setting up the Science and Technology Information Category [STCC].

On the other hand, Japan and West Germany held the seventh meeting of the information and documentation panel in Bonn in October 1986 under an agreement on bilateral cooperation in the fields of science and technology between the two countries. At the meeting the two countries agreed to promote the exchange of information and researchers in 11 fields relating to information and documentation. As to cooperation in the field of information technology under the same agreement, it was decided at the March 1987 meeting of the Japan-West German committee (11th) held in Tokyo to promote the exchange of researchers between the two countries.

Concerning the promotion of the exchange of science and technology information between Japan and developing countries, JICST has been making English translations of the information available to those countries as part of the ASCA science and technology information assistance program.

Part 3. Technology Trade and Patents

Patents, new designs for practical use and technical expertise are all generated as the fruits of the activities of research and development in science and technology fields. These fruits are being traded internationally in the forms of licensing and transferring the rights. These acts are called technology trade.

The value of technology trade and the number of patent applications reflect the level of research and development activities in science and technology fields in a country. Therefore, statistics on them are believed to serve as important indexes, indicating the technological standard and the capability for developing a new technology in a country.

The following will describe the recent situations in technology trade and patent applications in Japan.

1. Technology Trade

(1) Technology trade trends in Japan

According to the monthly Bank of Japan statistics on the international balance of payment, technology trade in Japan in FY 1987 registered \$1,385 million (¥200.3 billion) in export value, an increase of 37.3 percent (in dollar term comparison) over the preceding year, and \$4,177 million (¥604 billion) in import value, a gain of 23.8 percent. As a result, the export-to-import ratio of technology trade in Japan jumped from 0.30 in the preceding year to 0.33 in 1987 (Figure 2-3-1).

In FY 1986, the value of Japan's technology exports totaled ¥224.1 billion, a decline of 4.31 percent from the preceding year, while the value of imports stood at ¥260.6 billion, a decrease of 11.1 percent, according to the "Report on S&T Research" compiled by the Statistics Bureau of the Management Coordination Agency (Figure 2-3-2, appendix material 22).

As a result, the ratio of technology export-to-import in that year shot up to 0.86 from the preceding year's 0.80.

According to the agency's statistics, as far as the value of newly signed export/import contracts in a single year was concerned, the annual values of technology export have continually been higher than those of imports since FY 1972. In FY 1986, the value of exports reached ¥51.8 billion, while that of imports reached ¥33.6 billion. As for the value of newly contracted imports, it remained almost unchanged from the preceding year while the value of exports declined, making the export-to-import ratio decline from that of the preceding year (Figure 2-3-1).

As for the technology export by Japan's manufacturing industry in FY 1986, the electric machinery industry reached the top with ¥53 billion (a 10.9 percent loss from the preceding year), followed by the transportation machinery industry with ¥38.2 billion (a 35.4 percent gain), the chemical

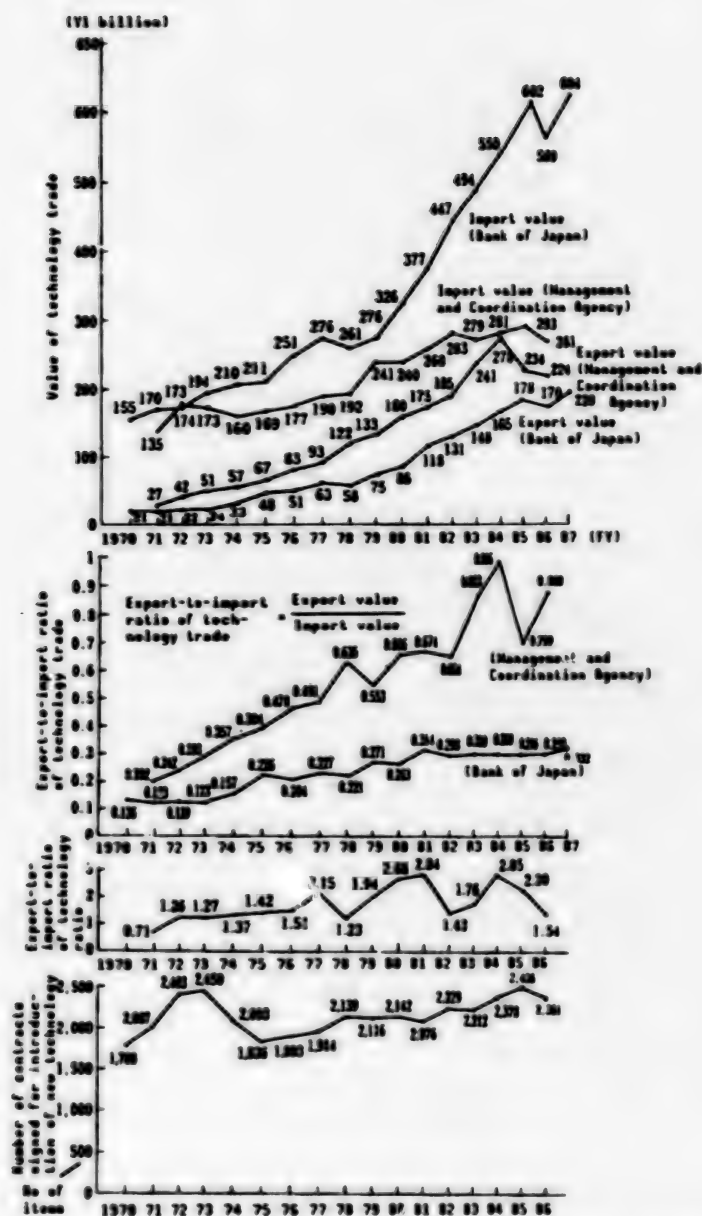


Figure 2-3-1. Shift in the Values of Japan's Technology Trade With Foreign Countries

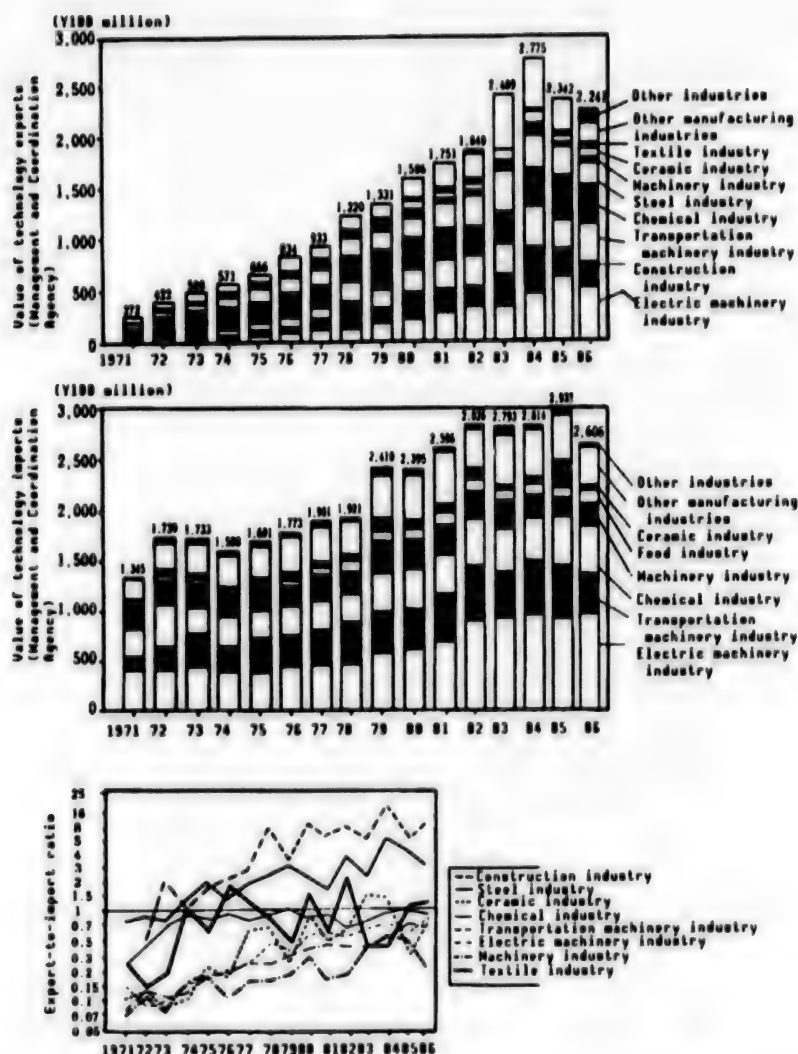


Figure 2-3-2. Shift in the Technological Balance of Payments by Industry
Source: "Report on S&T Research"

Notes: 1. In the above figure, the references to the Bank of Japan and the Management Coordination Agency represent the monthly statistics of the international balance of payment by the bank and the "Report on the S&T Research" by the agency, respectively.

2. The "newly contracted values" are the sums of new export and import contracts signed during a single year in international technology trade. The source of the values is the "Report on S&T Research."

3. The "number of contracts for the introduction of new technology" is the number of contracts Japan signed during a single year. The source of the number is "Annual Report on Introduction of Foreign Technology" by the Science and Technology Agency.

Until 1 December 1980, when the distinction was abolished, the contracts for the introduction of new technology were classified into two categories--a contract in which the period of validity of the

[Notes continued]

[Continuation of Notes to Figure 2-3-2]

contract or the period of payment lasts for more than 1 year, and a contract which does not fall under this category. The values of contracts signed before that data are the total of the values in the two categories.

4. Conversion to yen was done based on appendix material 33.

5. The reasons for the differences between the figures of the Bank of Japan and those of the Management Coordination Agency are:

(1) The method used to compile statistics: The Bank of Japan figures take into account the values of foreign exchange which were sent or received in payment for using patents, while the agency's figures take into account the values of all kinds of payments which were made by the domestic corporations covered in its survey in importing foreign technologies and exporting patents, know-how and technologies.

(2) The extent of industries covered: The bank's figures cover all the corporations and other domestic establishments whose business involves remitting foreign exchange, while the agency's figures include only those corporations conducting research and development, and exclude special corporation research institutes, the wholesale/retail industry and the service industry.

For the reason described in (1), when an industrial plant is exported and the payment for the technology included in the plant export is made with the remittance of exchange, it is not included in the Bank of Japan figures, creating the possibility of the bank figure registering a lower value of technology export than the counterpart figure tabulated by the agency. On the other hand, in the import of foreign technology, the fact that the values of technologies imported by Japan's tertiary industries, including department stores, and special corporations' research institutes are not included in the agency's figures, as described in (2), makes them register lower values than the corresponding ones by the Bank of Japan. [End Notes]

industry with ¥38.2 billion (unchanged) and the steel industry with ¥21.5 billion (a 17.8 percent decrease). As for technology import, the electric machinery industry led others with ¥91.3 billion (an 8.4 percent increase), followed by the transportation machinery industry with ¥49 billion (a 17.9 percent loss), the chemical industry with ¥40.6 billion (a 8.5 percent gain) and the machinery industry with ¥25.4 billion (a 3.8 percent gain).

The industries which chalked up technology export values higher than their import values were the construction and steel industries, with the construction industry enjoying the surpluses since FY 1975 and the steel industry since 1974.

According to the Science and Technology Agency's "Annual Report on Foreign Technology Import" (Figure 2-3-3, appendix material 23), in FY 1986 Japan's electric industry signed 934 new contracts for the import of foreign technologies (a 3.8 percent increase over the preceding year) and its machinery industry 395 new contracts (a 13.6 percent loss), followed by the chemical and clothing industries. Since FY 1980, the number of contracts in

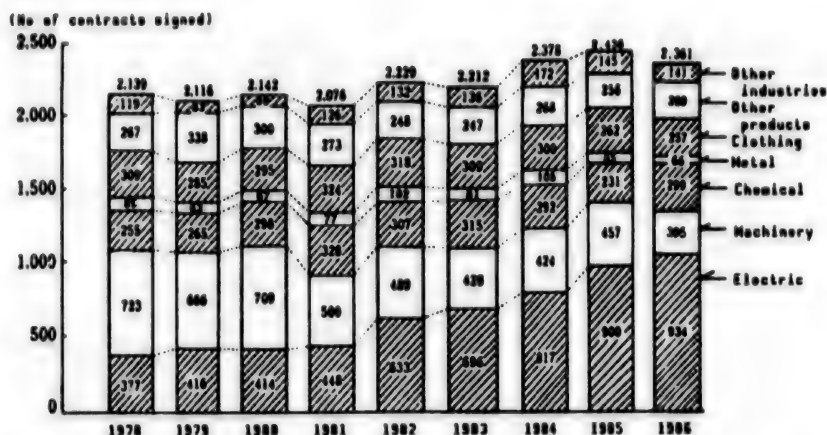


Figure 2-3-3. Shift in the Number of Contracts for Technology Introduction by Field

Note: The items "clothing" and "other products" correspond to "textile and textile products" and "other products" in appendix material 23.

Source: "Annual Report on Foreign Technology Introduction" by Science and Technology Agency

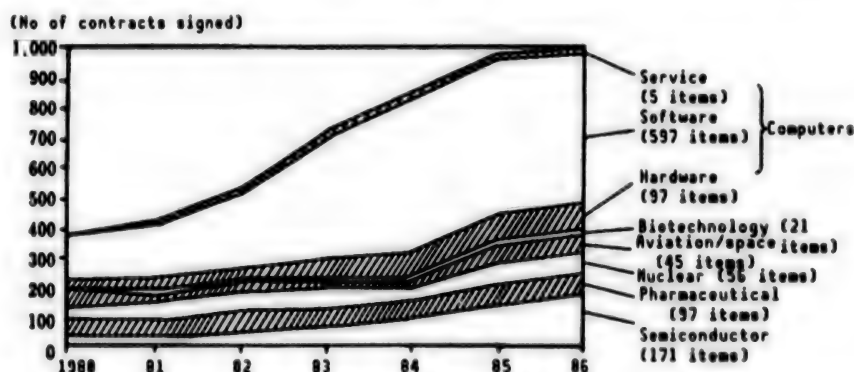


Figure 2-3-4. Trends in the Introduction of Foreign Technologies in High-Tech Fields

Source: "Annual Report on Foreign Technology Introduction"

the electric industry has been on the increase, while the number of contracts in the machinery industry has been decreasing.

As for the technology introduction in high-tech fields, the introduction technologies related to computers, particularly software technology, has grown significantly in recent years (Figure 2-3-4).

According to Japan's technological trade in FY 1986 (Figure 2-3-5), appendix material 23), Asia (excluding West Asia) was at the top with the amount of exports reaching ¥86.5 billion (a 1.2 percent decline from the preceding year). By country, China was the biggest customer with the value reaching ¥28.2 billion (including ¥8.5 billion for Taiwan), followed by South Korea

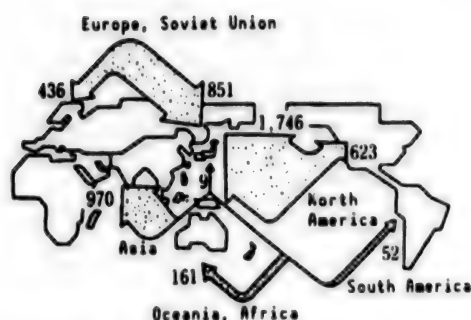


Figure 2-3-5. Destinations of Japan's Technological Trade by Country (FY 1986)

Source: "Report on S&T Research"

with ¥21.1 billion and Indonesia with ¥15.2 billion. The United States was the biggest single customer, with the export value reaching ¥57.7 billion (an 11.4 percent gain over FY 1985).

As for technology trades, the United States is the biggest supplier of technology, followed by European countries. In FY 1986, Japan imported technologies worth ¥173.8 billion (a 16.7 percent decline from FY 1985) from the United States, ¥20.7 billion (a 17.6 percent increase) from West Germany, ¥17.5 billion (a 7.4 percent gain) from Switzerland and ¥15.6 billion (a 0.6 percent increase) from the Netherlands.

As for technology exports, the electric machinery industry was the principal exporter to Asia (excluding West Asia), the construction industry to West Asia, the transportation machinery industry and electric machinery industry to North America, the steel industry to South Africa and the chemical, steel and electric machinery industries to Europe (Figure 2-3-6). In technology imports, the electric machinery and transportation machinery industries combined accounted for more than half of the value of Japan's technology imports from North America in FY 1986, while the electric machinery, chemical and transportation machinery industries combined represented more than 50 percent of the imports from Europe.

As for the number of new technology items imported in FY 1986, Japan imported 1,354 items (a 5.3 percent decrease from the preceding year) from the United States, followed by France with 212 items (a 7.1 percent gain), West Germany with 179 items (a 10.1 percent decline) and Great Britain with 149 items (a 10.2 percent decrease). The imports from these four countries combined accounted for 80.2 percent of the total number of new technology items imported during the fiscal year (Figure 2-3-7).

(2) Technology trade trends in major countries

As for the export of technology by major countries, the United States far outdistanced the other countries by exporting ¥1.307 billion worth of technology in 1987, followed by Japan with ¥187 billion (1987), Great Britain

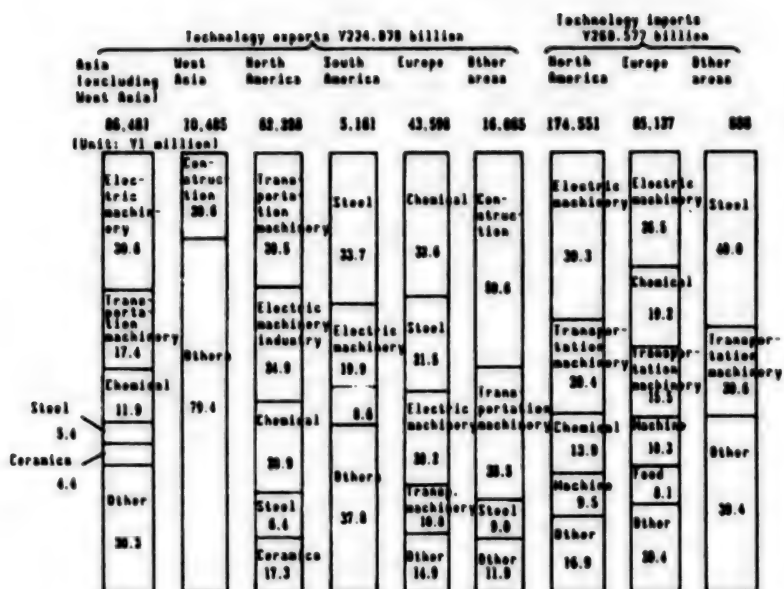


Figure 2-3-6. Contents of Japan's International Technological Trade by Industry (FY 1986)
Source: "Report on S&T Research"

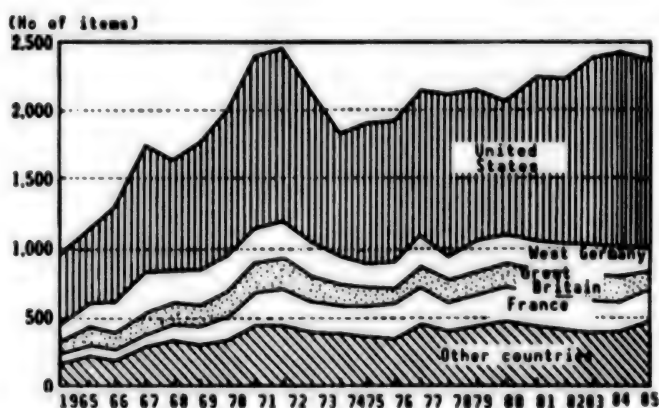


Figure 2-3-7. Shift in the Number of New Technology Items Imported From Major Countries
Source: "Annual Report on Foreign Technology Import" by the Science and Technology Agency

with ¥165.1 billion (1986), West Germany with ¥134.4 billion (1987) and France with ¥115.2 billion (1986) (Figure 2-3-8, appendix material 25).

On the other hand, in technology importing Japan reached the top by importing ¥551.5 billion worth of technology in 1987, followed by West Germany with ¥271.9 billion (1987), France with ¥207.6 billion (1986), Great Britain with ¥153 billion (1986) and the United States with ¥19.3 billion (1987).

Among these major countries, only the United States and Great Britain enjoy surpluses in the balance of international technology trade, with their

export-to-import ratios standing at 6.76 and 1.08, respectively. For West Germany, France and Japan, the values of imports surpassed those of exports, with the export-to-import ratios registering 0.49, 0.52 and 0.34, respectively.

[For the United States], the value of technology trade in 1987 increases from that of the preceding year, standing at ¥1.1137 trillion. Great Britain maintained surpluses in the balance of technology trade, however, the values were not as large. For West Germany and France, the values of imports were larger than those of exports, with the differences between the two values remaining almost unchanged for some years, at around ¥135.7 billion for each, respectively. For Japan, the technology trade deficit has been on the increase, reaching ¥364.5 billion in 1985.

2. Patent Applications

(1) Trends in patent applications in Japan

The number of patent applications in Japan has been increasing, reflecting the improvement of technological standards and the active efforts toward the development of technology in recent years. In 1987, the number of applications reached 341,095, an increase of 6.6 percent over that of the preceding year. On the other hand, the number of applications for designs of practical use has been leveling off since 1982, with the number standing at 201,614 in 1987 (a 1.3 percent loss from that of 1986) (Figure 2-3-9).

By field of technology, in 1986 the physics field generated patent applications for 82,267 items (26.4 percent in constituent ratio), electric field 75,235 items (24.1 percent) and processing/manipulation/transport fields combined 57,340 items (18.4 percent) (Figure 2-3-10). (Note: Category classification of an application for a patent or for a new design for practical use is made about 1 year after the application is accepted.) Compared to the preceding year, the physical sciences field registered a gain of 8.3 percent in the number of applications, the daily living goods field an increase of 7.6 percent, the electric field 5.9 percent, and the construction field a 4.9 percent gain, while the chemical/metallurgy/textile fields combined showed a gain of 4.7 percent and the processing/manipulation/transport fields combined demonstrated an increase of 1.5 percent. In contrast, the machinery engineering field suffered a 1.1 percent loss from the preceding year.

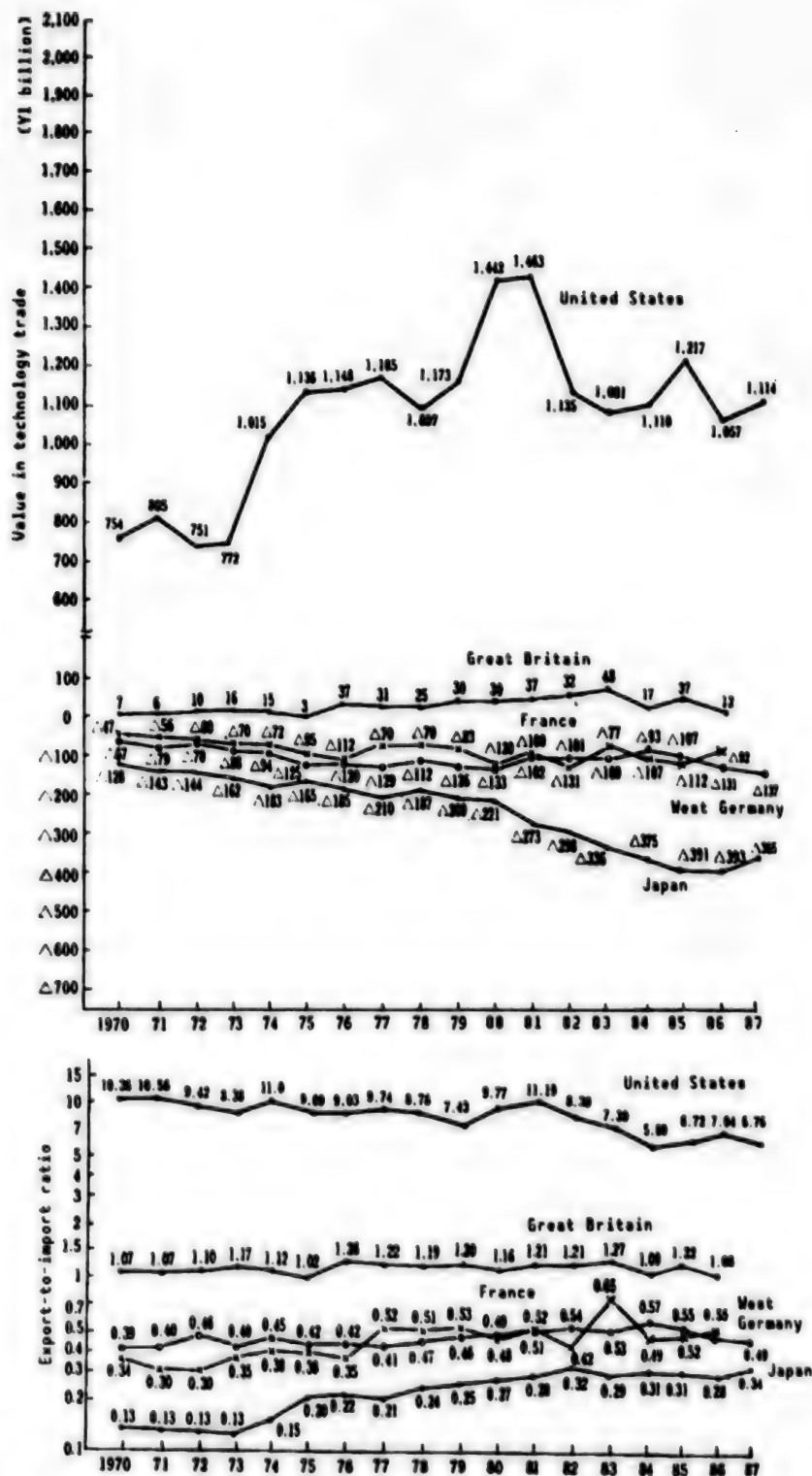


Figure 2-3-8. Shift in Values of Technology Trade and in Ratios of Technology Export-to-Import in Major Countries

- Notes: 1. Conversion to Japanese yen is based on appendix material 33.
2. For each of these countries the figures are for each calendar year.

[continued]

[Continuation of Figure 2-3-8]

Sources: Japan--Bank of Japan's monthly report on international payment statistics
 United States--"Survey of Current Business," Department of Commerce
 Great Britain--Department of Trade and Industry, "Business Monitor, Ma4,-Overseas Transactions," 1970-1984, "British Business," 1985-1986
 West Germany--Deutsche Bundesbank, "Monthly Report of the Deutsche Bundesbank"
 France--Ministers de l'Economie, des Finances et du Budget, "Statistiques & Etudes Financieres," "La Balance des Paiements de la France"

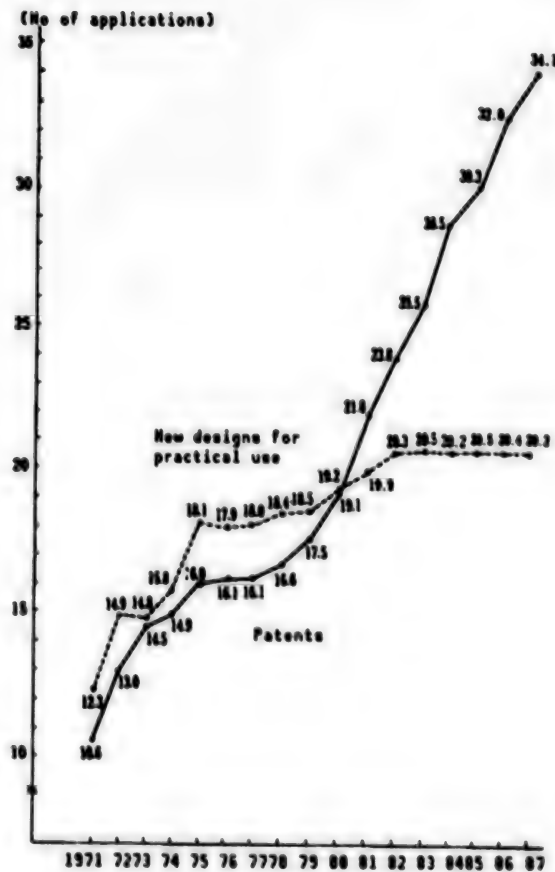


Figure 2-3-9. Shift in Numbers of Applications for Patents and New Designs for Practical Use

Source: "Annual Patent Office Report" compiled by the office

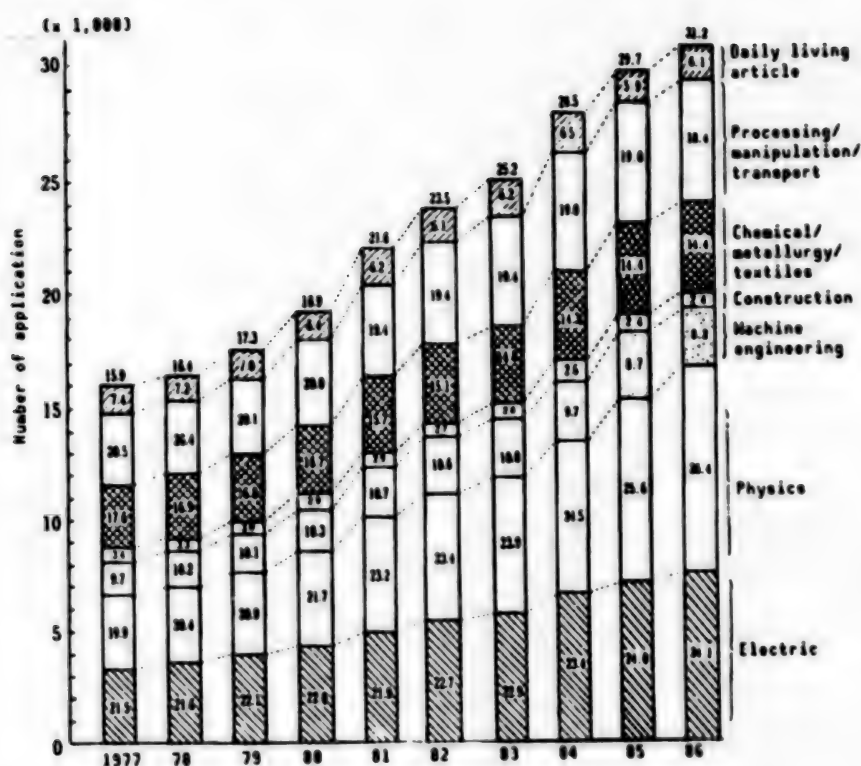


Figure 2-3-10. Shift in Number of Patent Applications by Industrial Sector

Notes: 1. The figures in the graph represent constituent ratios in percent.

2. The number of applications for each of the years represents the number of applications to which category classification was given.

Source: "Annual Patent Office Report"

For the past few years, the number of applications by foreigners for patents in Japan has been increasing gradually. In 1987, the number of these applications stood at 30,089, an increase of 0.7 percent over that of the preceding year (Figure 2-3-11).

By nationality, the United States accounted for 42.7 percent of these applicants, West Germany 19.4 percent, France 6.5 percent, Great Britain 6.4 percent and Switzerland 4.4 percent, respectively (Figure 2-3-12).

By field of application of the foreign patent applications, the chemical/metallurgy/textile fields combined represented 16.9 percent, followed by daily living goods at 12.5 percent, machine engineering at 9.6 percent and processing/manipulation/transport fields combined at 8.6 percent (Table 2-3-13).

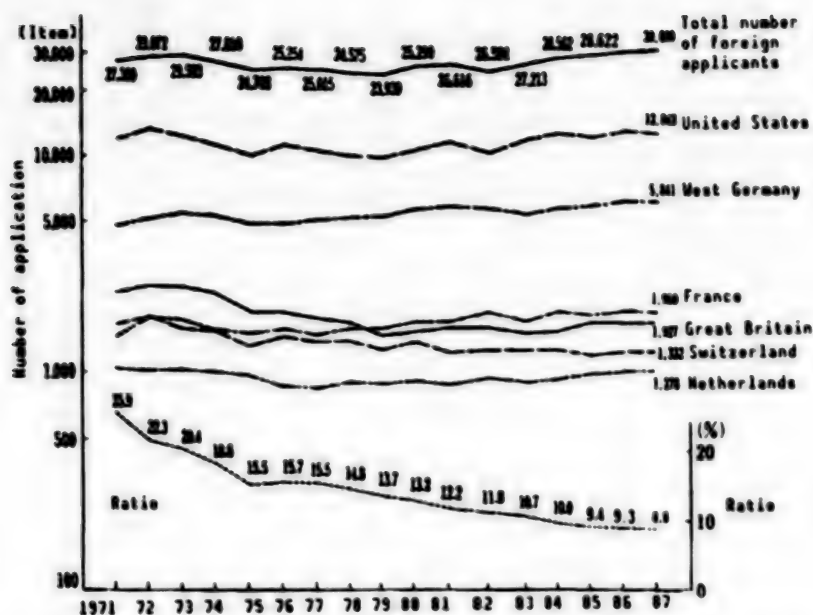


Figure 2-3-11. Shift in Number of Patent Applications in Japan by Foreigners

Source: "Annual Patent Office Report"

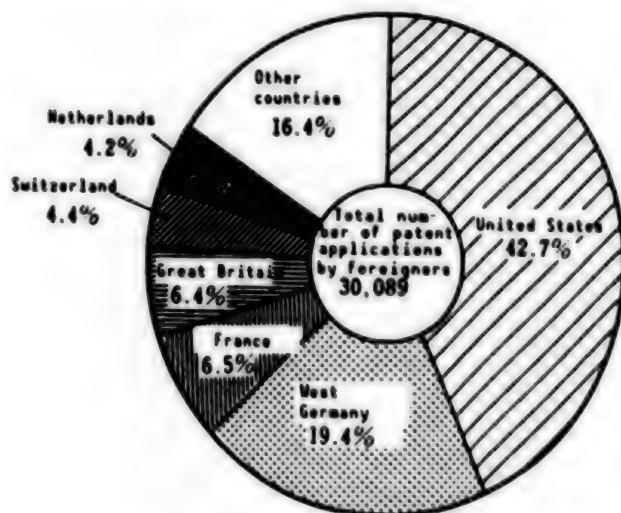


Figure 2-3-12. Percentages of Foreign Applicants by Nationality (1987)

Table 2-3-13. Shift in Percentage of Foreign Applicants for Patents in Japan by Industrial Sector

(Unit: percent)

Sector of industry \ Year	1978	1979	1980	1981	1982	1983	1984	1985	1986
Daily living articles	15.9	15.6	16.1	15.3	15.1	15.5	14.2	12.6	12.5
Processing/manipulation/transport	15.5	14.5	13.3	13.2	11.5	10.6	10.1	8.7	8.6
Chemical/metallurgy/textiles	25.6	23.9	23.7	23.3	21.0	20.2	19.4	17.8	16.9
Construction	11.1	10.9	10.7	10.2	8.9	8.3	8.2	6.4	6.3
Machine engineering	17.3	16.9	15.3	13.4	11.7	11.5	10.6	10.2	9.6
Physical	11.0	10.2	9.2	8.0	7.5	7.1	6.3	5.3	5.0
Electric	8.8	8.5	8.2	7.7	6.9	6.7	6.1	5.2	5.3
Average	14.9	14.1	13.3	12.	11.	10.6	9.8	8.6	8.3

Source: "Annual Patent Office Report"

(2) Japanese applications for patents in foreign countries

In 1986, the number of applications by Japanese individuals and companies for patents in foreign countries reached 48,891, including applications for patents under the European Patent Contention (EPC), a decrease of 742 applications (1.5 percent) from the year before (Figure 2-3-14). (Note) (Applications for European patents (under EPC). In Europe, the EPC was put into effect in 1977 and in June 1978 the European Patent Office (EPO) began accepting EPC applications. If a patent has been granted to an application by the EPO, it is recognized as a full-fledged patent within any of the EPC member countries just as a patent granted under the relevant domestic laws in those countries would. As of March 1988, EPC had 13 member countries.)

The United States was the most popular country for patent applications by Japanese applicants, attracting 45.5 percent of all Japanese applications outside Japan. It was followed by EPC applications (12.2 percent), West Germany (7.9 percent), South Korea (7.1 percent), Canada (6.4 percent) and Great Britain (5 percent) (Figure 2-3-15).

The numbers of Japanese [patent] applications in European countries have been decreasing in recent years. However, when taking the number of EPC applications into account, the number of Japanese applications in European countries, as a whole, is increasing.

The percentage of Japanese applications among those patent applications accepted by major foreign and EPC region countries has been decreasing, except in Canada, in recent years (Table 2-3-16).

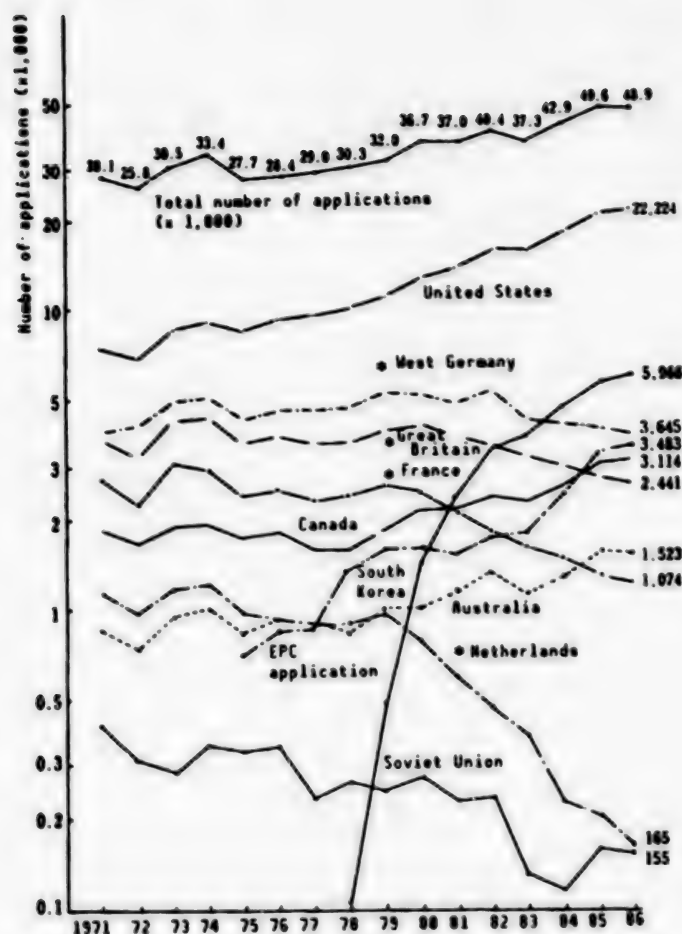


Figure 2-3-14. Shift in Numbers of Japanese Applications for Patents in Major Countries and the EPC Region

- Notes: 1. The number of applications does not include applications under the Patent Cooperation Treaty (PCT).
 2. The countries with an asterisk are EPC member countries.
 3. For South Korea, no data are available for the years before 1974.

Source: "Industrial Property Statistics," published by the World Intellectual Property Organization (WIPO) and an annual report by the European Patent Office.

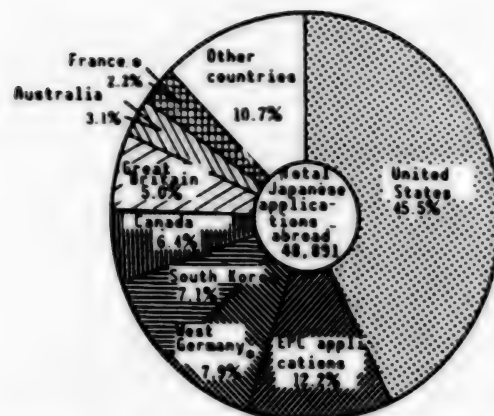


Figure 2-3-15. Breakdown of Japanese Applications for Patents in Foreign Countries (1986)

Note: The countries with an asterisk are EPC member countries.

Source: Refer to Figure 2-3-14.

Table 2-3-16. Shift in Percentage of Japanese Applications Among the Patent Applications Accepted by Major Foreign and EPC Region Countries

(Unit: percent)

Year	1970	1975	1980	1981	1982	1983	1984	1985	1986
Name of country									
United States	5.1	8.5	12.4	13.2	14.7	15.4	16.6	19.0	18.9
West Germany	5.8	7.2	10.8	10.6	11.3	9.3	9.4	9.2	9.0
Canada	5.8	6.8	8.1	8.7	9.7	9.2	9.9	11.1	11.2
Great Britain	5.8	6.8	10.1	9.8	9.8	9.5	9.5	8.9	7.8
France	5.3	6.0	8.9	8.8	8.3	7.7	7.4	6.8	5.8
Netherlands	6.5	6.4	10.7	9.8	9.2	8.5	5.8	5.7	5.0
Switzerland	3.4	4.1	5.7	5.2	5.2	4.3	3.9	3.3	2.8
EPC applications	—	—	8.3	10.9	13.8	13.7	14.6	17.2	16.2

Source: "Refer to Figure 2-3-14.

(3) Patent application trends in major countries/regions

Among major countries, Japan ranks first in the number of patent applications accepted by a single country--in 1986 the number of applications reached 320,089. Japan was followed by the Soviet Union with 171,179 (including applications and inventor certificates), the United States with 117,392, West Germany with 52, EPC region countries with 36,783 and Great Britain with 31,103 (Figure 2-3-17).

The numbers of patent applications accepted by West Germany and Great Britain have tended to slip during recent years. However, when the number of EPC applications is taken into account, it can be said that the number of applications in European countries, on the whole, is increasing. The acceptance of patent applications under the EPC began in 1978.

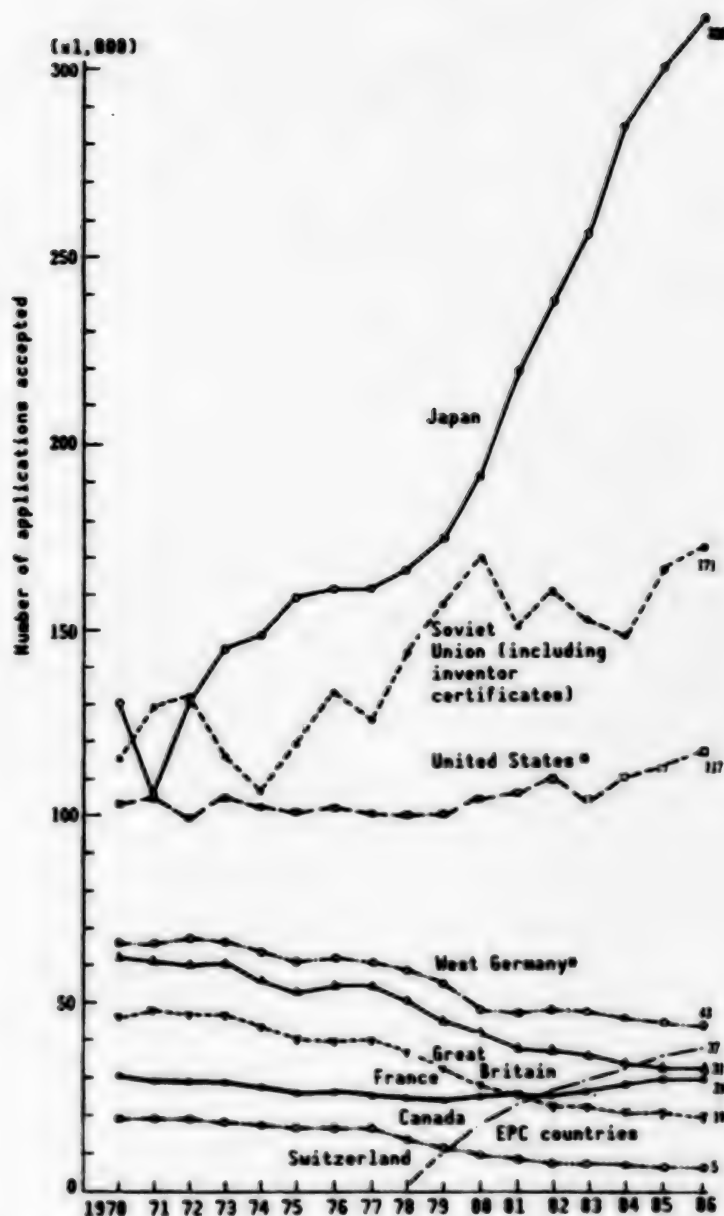


Figure 2-3-17. Shift in Numbers of Patent Applications in Major and EPC Region Countries

Notes: 1. The number of applications does not include applications under PCT.

2. The countries with an asterisk are EPC member countries.

Source: Refer to Figure 2-3-14.

Part 4. Trends in International Exchanges

In order for its prominence and prosperity to continue in the increasingly harsher international environment, Japan must try to make the best use of its human resources to further enhance the levels of science and technology and, at the same time, make efforts to use them to help build a harmonious international society by promoting international cooperation and exchanges in the fields of science and technology.

In recent years, the world has been witnessing deterioration represented by the depletion of natural resources, as well as problems involving energy conservation, food shortages, the natural environment and population. None of these problems can be solved through the efforts of a single country, and under the circumstances it is becoming increasingly important for the countries of the world to muster their powers of science and technology to tackle these global problems. In addition, progress in science and technology is thought to provide a major driving force for the growth of world economies. In view of this, the importance of developing science and technology and promoting international cooperation in these fields has been mounting in recent years. In recognition of this, at the economic summit of major industrialized countries held in Versailles in June 1982, French President Francois Mitterrand proposed, for the first time at such an economic summit, that the topic of science be discussed in connection with a discussion of the revitalization of the international economy and the promotion of economic growth. At the summit, the participants recognized the importance of promoting research on science and technology for the revitalization of the international economy and, based on that recognition, they agreed to establish a working session to study the problems concerning technology, economic growth and employment.

At the June 1987 Venice summit, Japan proposed that a "human frontier science program" be launched and the participants welcomed this proposal. At the Toronto summit held in June 1988, Japan announced that a feasibility study for the program had been completed with the cooperation of other countries participating in the summit. The economic declaration issued at the end of the summit included a passage expressing the hopes of the countries involved that Japan would announce a proposal for the implementation of the program in the near future.

In order to promote further cooperation with developing countries in the fields of science and technology, it is important that Japan extend cooperation in a way that will help these countries nurture their abilities to proceed with research and development on their own and to develop the kind of technology suitable for use in their countries. In promoting this cooperation, it is important to pay attention to the balance between research cooperation and technological cooperation. In this chapter, this white paper will describe Japan's international exchange and cooperation activities based on agreements in the summits, Japan-ASEAN ministerial conferences on S&T matters and on bilateral agreements involving S&T field cooperation, as well as international exchange and cooperation activities through the United Nations and the Organization for Economic Cooperation and Development (OECD).

1. International Cooperation Based on Summit Agreements

At the May 1986 Tokyo summit the final report on the review of the 18 international cooperation projects, which were initiated based on the agreements reached at the May 1983 Williamsburg summit, was presented at the working sessions for the study of problems concerning technology, economic growth and employment, and participating heads of state expressed their gratitude for the progress reported at the session. (Interim progress reports had been made at the working sessions at the May 1983 Williamsburg summit, the June 1984 London summit and the May 1985 Bonn summit, respectively).

At the Tokyo summit, agreement was reached on promoting international cooperation in the implementation of the projects. Among those projects, Japan has been assuming the leadership in promoting research and development in the fields of photosynthesis, solar electricity generation and high-tech robots. In addition, Japan plays important roles in other projects in the fields of biotechnology, the development of new materials and its standardization, remote sensing from space, fast breeder reactors, controlled thermonuclear fusion, biochemistry and marine resource cultivation.

As to the progress in the efforts toward "the improvement of environment measurement technology and the coordination of the measurement practice," a goal agreed upon at the Bonn summit, the call for a progress report to be made at the earliest possible time was included in the economic declaration [of the Tokyo summit].

On the other hand, at the June 1987 Venice summit, Japan proposed the launching of a "human frontier science program," and this was welcomed by the participating leaders of the major industrialized countries.

At the June 1988 Toronto summit, the completion of a feasibility study for launching the science program successfully was announced, and the economic declaration included a passage expressing the hopes of the participating countries that Japan would announce its proposals for the implementation of the program in the near future.

2. Japan-ASEAN Cooperation in S&T Fields

Former Prime Minister Yasuhiro Nakasone, while visiting five ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore and Thailand) and Brunei (which became an independent nation in January 1984 and joined ASEAN in the same month) from April to May 1983, proposed the establishment of a Japan-ASEAN ministerial conference to promote cooperation between Japan and ASEAN countries in science and technology fields, and secured the consent of the leaders of those ASEAN countries.

In December 1983, the first meeting of Japan-ASEAN ministerial conference to discuss cooperation was held in Tokyo after a series of working-level meetings attended by high-ranking officials from both sides.

The ministerial conference opened with an address by Nakasone. It was attended on the Japanese side by then Foreign Minister Shintaro Abe and the head of the Science and Technology Agency, and on the ASEAN side by the ministers in charge of science and technology affairs representing those ASEAN countries. At the meeting, they agreed to promote science and technology cooperation between Japan and ASEAN countries and to hold more working-level meetings to be attended by high-level officials in FY 1984.

Based on the agreements, a high-level meeting was held in Djakarta in December 1984, and new agreements were reached in biotechnology, microelectronics and material science. Following the agreement, the dispatching of Japanese specialists to ASEAN countries was initiated.

As for the cooperation in those three fields, Japanese technical cooperation continues in the material science field through project implementation.

3. Japanese Activities in International Organizations

(1) United Nations

At the United Nations, Japan plays active roles in tackling the global problems concerning natural resources, energy, food, the climate, the natural environment and natural disasters through the activities of various U.N. committees and U.N.-affiliated organizations. Specifically, it places importance on the advancing science and technology standards in developing countries, which suffer the most from many of these problems, to contribute to solving the North-South problems from a long-term perspective.

(1) United Nations conference on S&T for development

The ninth meeting of the Intergovernmental Committee for Science and Technology Development (ICSTD), which was set up as a follow-up to the "Vienna action program for science and technology development" adopted at the August 1979 meeting of the United Nations Conference on Science and Technology for Development (UNCSTD), was held in New York from July to August 1987. At the meeting, the topics for discussion included the utilization of science and technology to prevent natural disasters, such as those caused by the spread of deserts. At the meeting, it was decided to review the progress of the Vienna action program at the next ICSTD meeting since the program would shortly be marking its 10th year of operation.

Japan has been dispatching experts to serve as members of the Advisory Committee for Science and Technology Development (ACSTD), an advisory body to the ICSTD, ever since its establishment.

(ii) U.N. conference on new and renewable sources of energy

This international forum was set up to implement the Nairobi action program adopted at the U.N. conference for promoting reusable energy recycling, held in Nairobi, Kenya, in August 1981, to promote the development and utilization

of reusable energy, such as solar and wind power, particularly in developing countries, to supplement their future domestic power needs.

So far, the committee has held four meetings to discuss the implementation of the program.

(iii) United Nations Development Program

The United Nations Development Program (UNDP) is the principal financing organization for projects involving multilateral technological cooperation. In science and technology fields, technological cooperation is being promoted with monetary support from "the fund for the development of science and technology," which was established in January 1987, in addition to the funds from the UNDP.

(iv) United Nations Conference on Trade and Development

The United Nations Conference on Trade and Development (UNCTAD), which deals with the North-South problems from the aspect of global trade and development, is now working out a code for the transfer of technology--mainly to developing countries.

Agreement on all details of the code was not reached at the sixth UNCTAD meeting held in May 1985, so the matter must be discussed again at another meeting.

(v) Economic and Social Commission for Asia and the Pacific

The Economic and Social Commission for Asia and the Pacific (ESCAP) is engaged in activities for the development of Asia and the Pacific regions, and it is promoting a number of projects, including ones for technology transfer and the development of natural resources.

Japan has been extending financial and technological cooperation to ESCAP activities in various fields, and has also been extending active cooperation to ESCAP projects.

(vi) United Nations Environment Plan

The function of the United Nations Environment Plan (UNEP) is to coordinate the environment-related activities of various U.N. organizations and to promote international cooperation to solve environmental problems. The 14th meeting of UNEP was held in June 1987 in Nairobi, where its secretariat is located, and the participants engaged in animated discussions of the project to prevent the spread of deserts and related programs to be financed by the environment-related funds.

(vii) Third United Nations Conference on the Law of the Sea

The third conference on the Law of the Sea opened in 1973 to review the traditional international law of the sea in order to work out a new law

meeting the requirements of a new age, and efforts were made to hammer out international agreements on a number of problems related to exclusive economic zones, the continental shelf, the exploitation of mineral resources on the ocean floor, the protection of marine environments and the scientific investigation of the oceans. After deliberations which lasted more than 9 years, the new Law of the Sea was adopted by 117 countries and two regions from around the world at a conference in Jamaica in December 1982, which was convened for the signing of the final agreement and the United Nations Convention on the Law of the Sea. The law will take effect 1 year after the number of countries and regions either ratifying the convention or officially signing the treaty has reached 60. A new order will be ushered into the international seas when the law takes effect.

(vii) Committee for Peaceful Use of Outer Space

This committee was set up to promote international cooperation in the utilization of outer space and to deal with the legal matters arising from this utilization. The committee has two subcommittees: one for dealing with technological matters and the other specifically for handling legal matters. The committee has played important roles in connection with the Treaty on Principles Covering the Activities of States on the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, an agreement involving saving and repatriation, a treaty on damage compensation, a registration treaty, an agreement on the moon, and in working out the principles for the utilization of TV broadcasting satellites and ones for remote sensing. The committee is currently deliberating on various issues, including nuclear-powered satellites, a definition of outer space/geostationary orbit and on the progress made so far in the implementation of the recommendations adopted at the second meeting of the United Nations Conference on Exploration and Peaceful Uses of Outer Space (UNISPACE82).

(ix) United Nations University

The United Nations University is the only U.N. organization which is headquartered in Japan. The university was set up to contribute to solving global and urgent problems for the existence and development of mankind and to promote the welfare of the people, using the networks linking the university headquarters in Tokyo to its research and training centers as well as to cooperating universities and research institutes around the world. Japan has contributed \$100 million to the university and, under an agreement with the United Nations, the facilities at the temporary investment office in Tokyo are being used to run university activities. The preparation for building a university headquarters building was started in FY 1982, and an agreement was reached to start the construction in FY 1988. The following programs on five themes are currently being promoted for research, training and the dissemination of knowledge: 1) peace, security, ending international conflicts and changing the world; 2) the international economy; 3) starvation, poverty, resources and the environment; 4) the development of mankind and society, different human races, culture and the coexistence of different social systems; and 5) science and technology and their social and ethical effects.

Japan is contributing to these programs by extending cooperation through the Ministry of Agriculture, Forestry and Fisheries' National Food Research Institute and the governmental Institute of Developing Economies, and through the cooperation extended by Kagoshima University. The U.N. University and other international academic and research organizations are also involved in these programs.

(2) Specialized U.N. agencies and IAEA

These specialized agencies are international organizations having cooperative relationships with the United Nations under the accord based on Articles 57 and 63 of the Charter. In the fields of science and technology, the United Nations Educational Scientific and Cultural Organization (UNESCO) and the World Health Organization (WHO) are implementing programs and promoting activities in various fields based on their respective charters.

(1) UNESCO

UNESCO is promoting international cooperation in various fields of science and technology. Japan has extended cooperation to various UNESCO activities in past years. In the field of basic science, Tokyo Institute of Technology inaugurated a course in "UNESCO chemistry" and an "international postgraduate training course in chemical engineering" at the university in 1965, and still maintains them. Osaka University, in cooperation with other Japanese academic institutions, began to offer an "international postgraduate training course in UNESCO microorganisms" in 1973, and has accepted students every year since. In addition, ever since 1975, Japan has been contributing money to UNESCO's trust fund (\$100,000 in FY 1987) for use in promoting the establishment of an educational network in the basic science field to guide young researchers in Southeast Asian countries to engage in research on microorganisms and natural resource chemistry. A number of training courses are currently being offered through the network linking many universities and other research institutions in Japan and other countries. The exchange of researchers is also being promoted.

In the fields of hydrology and ecological research, a number of projects are currently being promoted, including an international hydrology plan (IHP), a man-and-biological sphere plan (MAB) and an international geological comparison plan (IGCP). In the field of oceanography, the Intergovernmental Oceanographical Committee (IOC) has been established. All are long-term intergovernmental joint projects aimed at better understanding the actual conditions of the earth, which provides human beings with their living environment, and at searching for the basic scientific means to promote the more rational use of natural resources and to preserve the natural environment. In these projects, Japan plays major roles in the implementation of joint investigative works.

Since FY 1981, Japan has been contributing money to UNESCO's trust fund (\$30,000 in FY 1987) to promote the IOS's program for a joint exploration of the Western Pacific (WESTPAC). A number of Japanese vessels participated in

the exploration: They include a research ship, *Hakuo Maru*, from Tokyo University's Ocean Research Institute, *Ryofu Maru*, a marine observation ship from the Meteorological Agency, and *Takyu*, a survey ship from the Maritime Safety Agency's Hydrographic Department. During the exploration, many foreign researchers participating were invited aboard these Japanese vessels to conduct joint research and investigation. In addition, the Hydrographic Department has been accepting foreign researchers for training at its marine data center for the management of marine data by offering short-term training courses. To promote the MAB project in Southeast Asian countries, Japan has been contributing money (\$20,000 in FY 1987) to UNESCO's trust fund since 1983, and has also been giving seminars in Japan and a number of foreign countries. As for IGCP cooperation, every year since 1970 Kyushu University has offered an international course on geothermal energy jointly with UNESCO.

In the field of S&T information, UNESCO has been promoting an international S&T information system (UNISIST) project to promote the smoother and faster dissemination of the increasing volume of S&T information in the world today. The project is being implemented by paying attention to promoting exchanges of information among developed countries and promoting assistance in S&T fields to developing nations. In 1976, the general information project (GIP), aimed at improving the infrastructures in libraries and material/documentation service centers in many countries, was launched for implementation with the UNISIST project and Japan, as a member of the intergovernmental council responsible for promoting GIP, has been playing an active role. In addition, as part of GIP, Japan has been cooperating with the international series of publication data system (ISDS) project through the National Diet Library, which serves as the domestic center of the project. Japan is also involved in a project aimed at promoting exchanges of information and useful experiences in the field of science and technology in Asia and the Pacific regions (ASTINFO).

As for science and technology policy, many Asian countries have held individual ministerial meetings in an effort to increase their use of science and technology in promoting their country's development by formulating appropriate national policies supporting progress in science and technology. In the Asian region, joint ministerial meetings have been held twice so far, in 1968 and 1981, and the policy is being reviewed frequently in many of the countries in the region.

(ii) World Health Organization

The World Health Organization (WHO) aims at attaining the highest possible standards in promoting the health of people throughout the world, and Japan has been the second highest contributor of money to the organization to help its endeavors. In addition to the obligatory financial contribution, Japan has been voluntarily supplying money every year to other special WHO health projects, including the effort to combat AIDS. Along with this financial support, Japan is actively cooperating with various WHO programs by, for example, accepting trainees from foreign countries, dispatching specialists and sponsoring international conferences.

WHO and the Food and Agriculture Organization (FAO) are currently in the process of working out international food standards in the form of the joint food standard committee to ensure the health of consumers and to promote smooth and fair international food transactions. Japan is represented on the committee.

(iii) International Atomic Energy Agency

The International Atomic Energy Agency (IAEA) endeavors to maintain world peace and to promote the contribution of nuclear energy to the health and prosperity of mankind. As an executive country of IAEA, Japan dispatches its representatives to the general convention and meetings of the executive council to work out the agency's action policies. Japan is also involved actively in other IAEA activities and programs, including participating in various meetings of specialists, holding various meetings in Japan, dispatching experts as part of technological cooperation projects, accommodating foreign researchers studying in Japan and participating in the international thermonuclear fusion experimental reactor (ITER) project and the international nuclear information system (INIS). In August 1978, Japan signed the regional cooperation agreement (RCA) to promote research, development and training in nuclear science and technology among the IAEA member countries in Asia, the Pacific and the Far Eastern regions, and has been actively cooperating with the developing countries in Asia.

To prevent the spread of nuclear materials, IAEA has signed a security agreement with several countries and it is inspecting the nuclear facilities in those countries. With the increasing reliance on nuclear energy in many countries in recent years, the importance of the role IAEA plays is increasing. Under the circumstances, IAEA is studying ways to operate the nuclear nonproliferation measures more effectively. To back up the IAEA's effort technologically, Japan, the United States, West Germany and Great Britain have worked out plans designed to improve the technology involved in ensuring nonproliferation. In November 1981, Japan launched its plan (JASPAS) to back up the IAEA endeavors.

(iv) International Telecommunications Union

The International Telecommunications Union (ITU) is a specialized U.N. agency engaged in activities to maintain international cooperation in telecommunications, including telegraph, telephone, radio and television broadcasts, satellite communications and ISDN, to promote the technological assistance of developing countries, and to promote the development of telecommunications technology and the more effective operation of telecommunications services. The ITU's activities include: 1) research in telecommunications, the formulation of relevant regulations, the adoption of relevant decisions and the promotion of standardization; 2) the allocation of frequencies and efforts to remove transmission noise; 3) offering technological assistance to developing countries; and 4) the coordination of telecommunications means using outer space communications technology.

Japan is in the top group of monetary contributors to ITU and, as a country responsible for the management of the union, is involved in various ITU activities. The International Frequency Registration Board (IFRB), a permanent body affiliated with ITU, has many Japanese members, and Japanese nationals are also active in the research arms of the International Consultative Committee on Radio (CCIR) and the International Telegraph and Telephone Consultative Committee (CCITT) as chairman and vice chairman, respectively. At ITU committee meetings, many of the Japanese members' proposals involving systemic and technological matters have been adopted. As for technological cooperation, Japan has dispatched many specialists to developing countries and has accepted many people from foreign countries for training at domestic institutions.

(v) World Meteorological Organization

The World Meteorological Organization (WMO) is endeavoring to coordinate and promote international meteorological programs, indispensable for preventing natural calamities and promoting the more effective use of land and natural resources to ensure uninterrupted progress in social and economic activities worldwide. WMO's activities include: 1) promoting the establishment of a worldwide meteorological observation network; 2) promoting the establishment of a system for the speedy exchange of meteorological information; 3) standardizing the methods of meteorological observation and ensuring the publication of the results of the observation; and 4) promoting the use of meteorological information in the fields of aviation, marine transport and agriculture.

In the WMO, too, Japan is very influential in determining operation policy and in working out global-scale meteorological projects. Japan plays a central role in analyzing meteorological data, weather forecasting and communications in East Asia. In addition, since 1977 Japan has played a leading role in the operation of a global weather observation system by collecting weather information over a wide area of the earth using the geostationary meteorological satellite, Himawari. Japan also provides those Asian countries plagued by frequent typhoons with relevant information by constantly trying to improve the service. With the cooperation of the UNESCO's intergovernmental oceanographic committee and the International Civil Aviation Organization (ICAO), Japan serves as the East Asian center for WMO's marine information and aviation weather information services, respectively.

As for assistance to developing countries, Japan is actively promoting the transfer of technology and expertise to Southeast Asia, Africa, Central America and South America to help them in promoting domestic meteorological programs.

(3) Organization for Economic Cooperation and Development

The Organization for Economic Cooperation and Development (OECD) makes efforts to promote economic growth, the improvement of living standards, cooperation with developing countries and the expansion of world trade.

With the conviction that the introduction of science and technology is essential before progress can be made, OECD is pushing for the promotion of scientific and technological cooperation among its member countries.

Various OECD programs and activities are being carried out through the Committee for Science and Technology Policy (CSTP), Committee for Information, Computer and Communications Policy (ICCP), Industrial Committee, Environment Committee, Nuclear Energy Agency (NEA), International Energy Agency (IEA) and the International Road Research Project. Those programs and activities involve the exchange of opinions, useful experiences, information and researchers, the compilation of statistics and joint research among the member nations.

CSTP is promoting cooperation among its member countries in formulating science and technology policies in anticipation of contributing to the social and economic development of those countries. For this purpose, CSTP holds meetings of the ministers in charge of science and technology affairs, in addition to the regular meetings which are usually held twice a year. It has a number of groups of specialists to help it implement its tasks. The committee deals with international technological problems, technology transfer, the safety and regulation of biotechnological research, scientific research at universities and the exchange of opinions for the compilation of science and technology statistics, and conducts research and investigation.

In October 1987, the seventh ministerial meeting was held. Based on the results of deliberations at the meeting, CSTP worked out the "general framework concerning the common principles for international cooperation in science and technology," which led to OECD recommending this framework at the executive council meeting in April 1988.

On the other hand, at the committee's regular meetings the ICCP is studying the effects of policies concerning information communications service technology on the society and economy of a country. At the same time, the committee is making a detailed study of the questions involving telecommunications and information service through its panels of specialists.

In environmental areas, the Environment Committee extends, with the help of its subordinate panels of experts on the environment and energy, active cooperation to the member countries in light of the mounting concern about the deteriorating environment. Japan is also actively cooperating in the committee's activities.

OECD's international cooperation in the nuclear field is being implemented through NEA and Japan, as a regular member of the agency, attends its various meetings for the exchange of information. Japan is helping to build the NEA data bank and is participating in a number of international projects, including the (Halden) project, LOFT project and international (streaker) project.

IEA was established in November 1974, following the 1973 international oil crisis, to ensure the stable supply of the commodity under an agreement among

oil-importing countries. Since its establishment, the agency has been promoting oil storage for use in an emergency, limiting the demand, the sharing of oil, the conservation of energy and the development of alternative energy sources. The agency has also been studying the issue of promoting research for the development of new energy sources.

The Committee for Research and Development (CRD) was set up for the development of new energy. The committee is responsible for working out IEA's strategy for the research and development of new energy and verifying its effectiveness, nurturing an effective energy R&D program based on the regular review of energy R&D policies in various countries and its verification, and setting up and implementing a joint energy R&D project.

Japan is currently participating in about 20 programs in the categories of energy technology system analysis, energy conservation, fossil energy, nuclear fusion and reusable energy under the supervision of CRD.

(4) Asian science cooperation associations

The Asian Science Cooperation Association (ASCA) was established as the result of an agreement reached at the November 1970 ministerial meeting held in Manila at the call of the Philippine government. Following the first gathering in Manila, general meetings have been held nine times, with the last one being in Kuala Lumpur in October 1987.

In conformance with the purpose of its establishment, ASCA has been promoting scientific and technological activities, introducing science and technology to promote social and economic progress, and providing a forum for the candid exchange of opinions and experiences in the cooperation in science and technology fields. ASCA does not have a permanent secretariat, so the country serving as the host for the last meeting must assume the duties of the secretariat until the next gathering is held in another country.

In 1980, Japan started an ASCA S&T cooperative program in which English translations of Japanese research documents were made available to ASCA member countries. In addition, once a year Japan invites researchers from ASCA countries to present seminars on the themes which are of great interest to the ASCA countries. In March 1988, Japan gave such a seminar for the improvement of the network for cultured biological resource information.

On the other hand, Japan also extends cooperation to the International Board of Plant and Genetic Resources (IBPGR), an organization affiliated with the Cooperation Group for International Agriculture Research (CGIAR), for the preservation of rice, maize and wheat at the request of the board. In addition, Japan has dispatched specialists to other CGIAR-affiliated specialized organizations for joint research. Those organizations are the International Rice Research Institute (IRRI), the International Crop Research Institute for Semi-Arid Tropics (ICRISAT), the Center for International Agriculture in the Tropics (CIAT) and the International Laboratory for Research of Animal Diseases (ILRAD).

That the peaceful use of nuclear power and its nonproliferation can coexist was reconfirmed by the international nuclear fuel cycle evaluation (INFCE) conducted from 1977 through 1980. Following this reconfirmation, the effort to introduce a new international order to prevent the spread of nuclear materials has been under way at the International Atomic Energy Agency (IAEA) and other related international organizations.

On the other hand, Japan has been actively participating in the seabed survey conducted by the Committee for the Joint Exploration of Mineral Resources in Southern Pacific Coastal Seabeds (SOPAC) along the coasts of SOPAC member nations. The International Council of Scientific Union (ICSU), a nongovernmental international exchange promotion organization, promotes the use of science for the welfare of human beings, and it plays a particularly important role in the promotion of research activities at scientific institutions in natural sciences and as a coordinator for various international scientific organizations. Among the ICSU programs to which Japan extends cooperation, are the middle Atmosphere Program (MAP), a joint international observation program, a marine research program, and joint programs for research on international water resources and their rational utilization, on the living environment of human beings and plants and on genetics.

4. Bilateral Cooperation Activities

(1) Cooperation between Japan and Western countries

Bilateral cooperation between Japan and Western industrialized countries is being promoted to solve various problems common to those countries. This cooperation is currently being promoted in the development of nuclear energy, natural resources, space and marine-related research, as well as in the fields of biotechnology research and the protection of the environment. Japan's partners in such cooperation include the United States, France, West Germany, Canada and Australia. Among these countries, the cooperative relationship with the United States is particularly strong: bilateral cooperative agreements have been reached in energy and nonenergy field research and development activities and in the protection of the environment, and bilateral committees have been established to discuss the development of natural resources and other pending issues. Japan has signed bilateral cooperative agreements in science and technology fields with France, West Germany, Australia and Canada. In the following, this white paper will describe Japan's bilateral cooperation with those Western industrialized countries.

(1) Japan-U.S. cooperation

Ever since the establishment of the Japan-U.S. scientific cooperation committee, many bilateral cooperation agreements in the field of science and technology have been signed. Those accords include one which establishes the U.S.-Japan Council for the Development and Utilization of Natural Resources (UJNR), as well as intergovernmental accords for cooperation in the protection of the environment, for the joint research and development of

energy and related fields (signed in May 1979), and for the promotion of research and development in the fields of science and technology (May 1980).

The bilateral cooperation under the energy-related accord has been promoted mainly through joint projects in the fields of nuclear fusion, coal energy technology, the conversion of solar energy through photosynthesis, the exploitation of solar energy, geothermal energy and high energy physics. Among these projects, particular emphasis has been placed on the nuclear fusion and coal energy technology. The nuclear fusion project calls for the investment of huge research sums and many researchers representing a wide field of science, and it is expected that it will take a very long time to achieve fusion lasting long enough to generate usable energy. A joint project dubbed "Tablet III" is currently underway. Cooperation is also occurring in exchange programs and in the field of plasma physics. As for the coal energy development project, a Japan-U.S. agreement for its implementation was signed in May 1986. Regarding joint projects in other fields, an official document providing for Japan's cooperation in research directed toward achieving solar energy conversion through photosynthesis was exchanged between Japan and the United States in September 1981; an agreement for the implementation of a program in high-energy physics was reached in November 1979, and a similar agreement for the utilization of solar energy was signed in May 1982. Research in the fields of high-energy physics and the development of geothermal energy has long been underway between the two countries.

As for Japan's cooperation with the United States in research and development in nonenergy fields, cooperation has been extended in the fields of outer space research, life sciences, basic physics, the environment, disaster prevention, agriculture, forestry and fisheries. This cooperation has mainly taken the form of exchange of information and holding meetings of specialists. In June 1988, a new Japan-U.S. science and technology cooperation agreement was signed to push bilateral cooperation under a new framework.

UJNR was established following an agreement reached at the third meeting of the Japan-U.S. Joint Trade and Economic Committee held in January 1964. There are currently 17 affiliated panels of specialists and one subcommittee (Marine Resource Engineering Coordinating Committee (MRECC)) responsible for overseeing the activities of the seven marine-related panels under UJNR. UJNR is promoting cooperative activities in the fields of disaster prevention, medicine, the environment, marine research, agriculture, forestry and fisheries. In December 1985, the 11th general conference of UJNR was held in Tokyo to review the activities of the panels of specialists.

The Japan-U.S. Science and Technology Committee was established following an agreement reached during a discussion between former prime minister Hayato Ikeda and former president John F. Kennedy in June 1961. The committee has been promoting cooperative activities between Japan and the United States in the forms of joint research and seminars in the fields of science education, science and technology information, earth science, outer space science/astronomy, bioscience, agronomics/medicine, mathematics, physics/chemistry, engineering and interdisciplinary problems (including food science and marine

biology as special fields of research). The activities in these fields are mainly being implemented by the Japan Society for the Promotion of Science on the Japanese side and by the National Science Foundation on the American side. In October 1987, the 12th joint meeting of the directors was held in Tucson, Arizona.

In the medical field, the Japan-U.S. Medical Cooperation Committee was established as the result of an agreement reached at a discussion between former prime minister Eisaku Sato and former president Lyndon B. Johnson in 1965, and joint research has been promoted to combat disease in Asia.

Bilateral technological cooperation in the development of outer space has been promoted based on the agreements reached between the two countries. A study for the promotion of a new or joint project in the field of space development has been conducted under NASA's Standing Staff Liaison Group (SSLG) and the Space Development Council, a body set up under an agreement between the Space Development Committee and the National Aeronautics and Space Administration (NASA) in July 1979.

A program for launching a space station, as proposed by the United States, is currently being promoted jointly by the United States, Japan, Canada and European countries.

As for the nuclear field, under the old Japan-U.S. nuclear agreement signed in 1968 (part of the agreement was modified in 1973), Japan extended cooperation to the United States for the enrichment of uranium. In addition, Japanese cooperation has been offered concerning the fast breeder reactor, its safety measures and in the exchange of the regulatory information. At the May 1981 Japan-U.S. summit, Japan and the United States agreed that they would resume negotiations as soon as possible to solve the problems involved in resuming the operation of the Tokai nuclear fuel reprocessing plant and the construction of a new fuel reprocessing plant, two major issues in Japan-U.S. nuclear cooperation negotiations ongoing since 1977.

In June 1982, Ichiro Nakagawa, director-general of the Science and Technology Agency, visited the United States and discussed the reprocessing issue with American government leaders. During the discussions, Japan and the United States agreed to initiate negotiations as soon as possible in an effort to reach a comprehensive agreement on the reprocessing issue. Negotiations between Tokyo and Washington started 2 months later and, in November 1987, a new nuclear cooperation agreement, containing a prior consent clause, was signed by the two countries. The agreement took effect in July 1988. The agreement put the Japan-U.S. relationship involving nuclear cooperation on a stable foundation and ensured a more equal partnership between the two countries, with the United States making greater concessions in the reciprocity of the relevant restrictive regulations.

(ii) Japan-France cooperation

Based on the July 1974 Japan-France science and technology cooperation agreement, cooperation between the two countries has been promoted in the

fields of marine development, space development, biotechnology, science and technology information and the development of new materials through the exchange of information in these fields, the convening of specialists' meetings and by promoting joint research.

In the nuclear field, ever since the Japan-France nuclear agreement took effect in 1972, Japan has relied on France to reprocessing a portion of its spent nuclear fuel and, in the development of light water reactors, active cooperation between the two countries is being maintained for research to improve the safety of that type of reactor. The exchange of information on the relevant regulations is also occurring. Japan and France are currently studying a modification to the existing nuclear cooperation agreement aiming at ensuring a smoother flow of nuclear materials and technology between them.

(iii) Japan-West Germany cooperation

Since the signing of the Japan-West Germany science and technology cooperation agreement in October 1974, cooperation between the two countries has been promoted in the fields of marine science and technology, research toward nuclear reactor safety, high temperature gas-cooled reactors, biology/medicine, environmental protection technology, new energy technology, information/documentation, security measures, safety in the nuclear fuel cycle and space research. Special panels have been established to promote cooperation in all these fields, except for space research.

(iv) Cooperation between Japan and European Space Agency

Based on the exchange of notes between Japan and the predecessor of the European Space Agency (ESA), the 12th meeting of the administrative officials was held in Tokyo in April 1987 and opinions were exchanged on the topics of science, the observation of the earth, a transport system and the operation of this system.

(v) Japan-Canada cooperation

Following the first discussion on bilateral cooperation between Japan and Canada in the fields of science and technology which was held in 1972, six such meetings have been held so far, alternating between Japanese and Canadian locations. In May 1986, a Japan-Canada science and technology cooperation agreement was signed, and in September of the same year, the first meeting of the Japan-Canada Science and Technology Cooperation Committee was held.

Cooperation is currently being promoted between the two countries in the fields of energy, information, space communications, transportation, agriculture, forestry, the environment and disaster prevention through the exchange of information and meetings of specialists. The countries are also cooperating in tackling the problems involved in paving the roads in the cold northern regions and navigating through frozen seas.

In December 1974 and in the same month in 1976, Canada, the principal supplier of natural uranium to Japan, announced, in succession, uranium export policies aimed at strengthening the prevention of the spread of nuclear materials. Following this, Canada initiated a series of negotiations for a revision of the bilateral nuclear cooperation accords with the foreign countries concerned, including Japan, in accordance with the policy. After a series of negotiations which lasted slightly more than 1 year, Japan exchanged protocols for this revision with the Canadian government, and the new accord took effect in September 1980. This was followed by other negotiations to require Japan to secure the prior consent of the Canadian government when processing spent nuclear fuel or transferring nuclear materials to a third country. The notes of agreement were exchanged between Tokyo and Ottawa in 1983. Active cooperation concerning heavy water reactors, the handling of highly radioactive wastes, and the demolishing of old nuclear reactors is currently underway between the two countries.

(vi) Japan-Australia cooperation

In November 1980, Japan signed an agreement with Australia for cooperation in research and development in the fields of science and technology. This further bolstered the cooperative relationship between the two countries. At the fifth Japan-Australia ministerial conference held in June 1978, an agreement was reached concerning cooperation in energy development.

Bilateral cooperation is currently being maintained in the fields of biology, physics and marine science and technology.

In the field of energy development, cooperation is occurring in the liquefaction of coal and the tapping of solar energy.

In May 1977, Australia, a leading supplier of uranium to Japan, announced a new policy aimed at strengthening nuclear security measures and started negotiating with its customer countries to revise bilateral nuclear cooperation agreements. After participating in a series of negotiations which lasted more than 3 years, Japan signed a new agreement in March 1982, and the agreement took effect in August of the same year. The new agreement contains a provision for prior consent when reprocessing spent fuel and when transferring nuclear materials to a third country, and in this respect the agreement is more comprehensive and is intended for a longer term operation. Active cooperation is occurring in the handling of highly radioactive wastes.

(vii) Japan-European community cooperation

During high-level discussions between Japan and the European Community (EC) in 1982 and 1984, the EC proposed that cooperation in scientific and technological field be established, and an agreement was reached to promote bilateral cooperation in nuclear fusion, as well as in other fields.

At the December 1986 Japan-EC ministerial conference in Brussels, which was attended by Yataro Mitsubayashi, director-general of the Japanese Science and Technology Agency, the issue of establishing scientific and technological

cooperation was discussed. As for cooperation in nuclear fusion research, an agreement was reached calling for both sides to make efforts to sign a cooperation agreement as soon as possible. An agreement was also reached to promote the exchange of young researchers. Negotiations are currently under way for the signing of the nuclear fusion cooperation agreement.

(2) Cooperation between Japan and communist countries

Japan signed a Japan-Soviet science and technology cooperation agreement in October 1973. Researchers are currently being exchanged between the two countries based on agreement on the exchange of scholars, teachers and researchers, which took effect in December 1987. In the nuclear field, an agreement to promote bilateral cooperation in the fields of plasma physics and nuclear fusion was reached at the fourth meeting of the Japan-Soviet Science and Technology Cooperation Committee held in December 1987.

As for cooperation with East European countries, Japan signed bilateral science and technology cooperation agreements with Romania in April 1975, East Germany in November 1977, Bulgaria in March 1978, Czechoslovakia in November 1978, Hungary in May 1979 and with Poland in November 1978.

Japan signed a similar agreement with Yugoslavia in May 1981, which took effect in February 1982.

Under these agreements, Japan has invited many researchers from these East European countries for research and training in Japan.

(3) Cooperation with developing countries

(1) Japan-China cooperation

In May 1980, a Japan-China science and technology cooperation agreement was signed, and since then the Japan-China Science and Technology Cooperation Committee has met four times. The fourth meeting was held in Tokyo in May 1987, and an agreement to promote bilateral cooperation in 30 projects, including cooperation in marine research and natural resource development which has been maintained in the past, was reached. Starting with the fourth Japan-China ministerial conference which was held in July 1985, ministers in charge of science and technology affairs from both countries began to participate in similar meetings to exchange opinions on bilateral cooperation in science and technology fields.

In addition to the exchange of technology in agricultural and forestry fields, which has been maintained since 1973, cooperation in railways has been extended to China through the Japan International Cooperation Agency since 1978, while cooperation in business management and the medical field has been ongoing since 1979. The Ministry of Education has been accepting Chinese researchers dispatched by the Chinese government to engage in research in Japan. Other bilateral cooperation programs include the joint cosmic ray observation between Tokyo University's Cosmic Ray Laboratory and the Chinese Academy of Sciences's physics laboratory, cooperation in the

field of engineering between Tokyo University and the University of Science and Technology of China (Hefei), joint atmospheric observation using balloons between the Institute of Space and Astronautical Science and the Chinese Academy of Sciences/Shanghai astronomical observatory, and joint research for earthquake prediction between Tokyo University's Earthquake Research Institute and the State Seismological Bureau.

In addition, under the agreement, the Japan Society for the Promotion of Science has been promoting the exchange of researchers in the sciences with the Chinese Academy of Sciences since 1979, with the Chinese Academy of Social Sciences since 1980 and with the State Education Commission since 1981.

Starting with the third Japan-China ministerial conference held in June 1983, negotiations to promote cooperation in the peaceful use of nuclear energy were initiated. After six meetings, the agreement for the cooperation was signed on 31 July 1985, and it took effect on 10 July 1986.

(ii) Japan-Indonesia cooperation

In January 1981, the Japan-Indonesia science and technology cooperation agreement was signed and, under the agreement, the first Japan-Indonesia science and technology cooperation meeting was held in Djakarta in January 1982.

In March 1988, an agreement for promoting research involving the safety of research reactors and their utilization was signed by the Japan Atomic Energy Research Institute and Indonesia's National Atomic Energy Agency. The agency is currently operating a 30 MW multipurpose research reactor (MPR-30) on a test basis, and Japan has provided the agency with a neutron analyzer and has dispatched specialists to manipulate the analyzer.

(iii) Japan-South Korea Cooperation

The cooperation between Japan and South Korea in the fields of science and technology dates back to the first Japan-South Korea science and technology ministerial conference held in Seoul in September 1968. Ever since, bilateral cooperation in those fields has been promoted actively.

When South Korean President Chun Doo Hwan visited Japan in September 1984, he and former prime minister Yasuhiro Nakasone discussed bilateral science and technology cooperation and agreed to start negotiations toward the signing of a cooperation accord between the two countries. In December 1985, the Japan-South Korea science and technology cooperation agreement was signed, and in August 1986, the first meeting of the Japan-South Korea Science and Technology Cooperation was held. At the meeting, the two countries agreed to cooperate in various research fields, including biotechnology.

At a regular ministerial conference held in December of the same year, further promotion of bilateral cooperation in the fields of science and technology was discussed.

In the nuclear field, an agreement to start research on nuclear safety was concluded between the Japan Atomic Energy Research Institute and the South Korean Energy Research Institute in August 1985.

(iv) Japan-Brazil cooperation

The first meeting of the Japan-Brazil Science and Technology Cooperation Committee under the June 1985 Japan-Brazil science and technology cooperation agreement was held in Brasilia in October 1985. At the meeting, proposals were made for starting bilateral cooperation in research in fields of mutual interest, including energy and biotechnology. Japan and Brazil are currently negotiating for the realization of this cooperation.

(v) Japan-India cooperation

In September 1986, the first meeting of the Japan-India Science and Technology Cooperation Committee was held in Delhi, India, to discuss further bilateral cooperation between the two countries under the August 1985 cooperation agreement.

(vi) Japan's cooperation with developing countries

So far, Japan has been contributing to the enhancement of the levels of science and technology in developing countries by extending cooperation to them in science and technology.

Developing countries are in need of the technology which suits the needs of their countries. However, a developing country which cannot afford enough research money and has few competent researchers cannot develop such technology on its own. Under these circumstances, as was pointed out in Pearson's report and the United Nations' third 10-year international development strategy, industrially developed countries must extend cooperation to developing countries to promote research and help them develop new technology or improve existing technology to make it suitable for use in these countries.

Considering the active cooperation being extended by other industrially developed countries, Japan must step up its cooperation to developing countries.

In 1987, Japan's technological cooperation reached an equivalent of ¥168.7 billion, an increase of ¥25.7 billion or 18 percent over the ¥143 billion in 1986 (Figure 2-4-1).

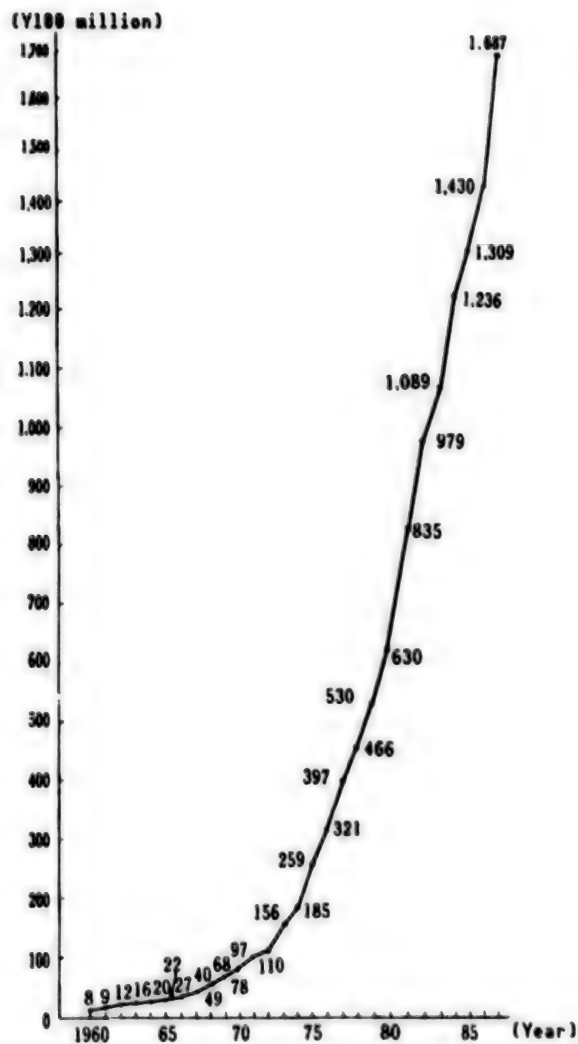


Figure 2-4-1. Shift in Value of Bilateral Technological Cooperation Extended by Japan
Source: A Foreign Ministry document

However, the ratio of the amount of money Japan used for bilateral technological cooperation against the sum of its official development assistance in 1986 (excluding administrative expenses and subsidies to nongovernmental organizations) stood at 10.6 percent (Figure 2-4-2). This compared with an average of 20.2 percent for the member countries of the OECD's Development Assistance Committee (DAC) in that year. The ratios of the values of bilateral technological cooperation by the DAC member countries against the year's total value in 1986 were: Japan accounting for 8.1 percent, France 26.6 percent, the United States 20.4 percent and West Germany 16.6 percent.

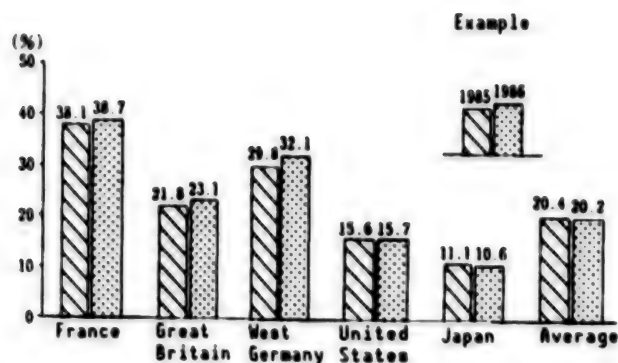


Figure 2-4-2. The Ratios of Values of Bilateral Technological Cooperation Against the Values of Official Development Assistance in the Member Countries of the OECD's Development Assistance Committee

Source: A DAC document.

The Japanese government is extending technological cooperation in the forms of acceptance of foreign researchers for training, the dispatch of experts, providing equipment and materials, the promotion of a project in which all these are integrated, conducting a survey for development (excluding mining and electric industries) and the dispatch of Japan Overseas Cooperation Volunteers (all are being carried out by the Japan International Cooperation Agency (JICA), with subsidies provided by the Foreign Ministry). In addition, there is an investigation for overseas development plans and a basic survey for cooperation in natural resource development, both of which are being implemented by JICA with subsidies provided by the Ministry of International Trade and Industry (MITI).

On the other hand, the Ministry of Agriculture, Forestry and Fisheries has been extending cooperation to research in the fields of agriculture, forestry and livestock industries in tropical and subtropical regions through a tropical agriculture research center, established in 1970. Since FY 1973, MITI has been promoting international industrial technology research programs, focusing on mining industry technology, in its effort to extend technological cooperation to developing countries using the testing and research facilities of its Agency of Industrial Science and Technology. In addition, MITI has been promoting other projects aimed at stepping up the research and development cooperation extended to developing countries and at promoting joint research, by positively enlisting the R&D resources of the private sector. Beginning in FY 1976, the Science and Technology Agency and the Ministry of Construction have joined endeavors to promote research cooperation to developing countries. Specifically, since FY 1986 the agency has been accepting researchers from South Korea, China, Indonesia, Malaysia and Thailand, and has been dispatching Japanese experts to these countries under the bilateral nuclear research exchange systems. The Ministry of Education started its exchange program in the sciences, which is being implemented by the Japan Society for the Promotion of Science, in FY 1976. In FY 1978, the ministry expanded its cooperation program by accommodating foreign researchers engaged in research at the nation's universities.

On the other hand, cooperation in developing countries is also being extended by the private sector. In addition, considerable cooperation is also being extended by the private sector, with these efforts either being subsidized by the government or entrusted by government ministries and agencies. This cooperation includes one project extended by the International Development Center that had been entrusted by government agencies in the survey for development projects; one by the International Nurse Exchange Association entrusted by the Ministry of Health and Welfare as a nurse training program; one by the International Welfare Works entrusted by the Ministry of Health and Welfare for nurturing specialists in the administration of pharmaceutical policies; one by the Overseas Agricultural Development Association subsidized by the Ministry of Agriculture, Forestry and Fisheries to promote overseas agricultural and forestry development cooperation; one by the Overseas Agriculture Development Consultant Association subsidized by the ministry in the survey for overseas agricultural development projects; technological cooperation to small- and medium-sized enterprises in developing countries by the Japan Plant Association subsidized by MITI; one by the Overseas Consulting Firm Association subsidized by MITI for promoting overseas consulting businesses; technological cooperation in the field of transport-related technology by the Overseas Transportation Consultant Association subsidized by the Ministry of Transportation; one by the Overseas Communications/Broadcast Consulting Association subsidized by the Ministry of Posts and Telecommunications for overseas communications projects; and one by the International Construction Technology Association entrusted by the Ministry of Construction for overseas construction technology development programs and involving the preparatory survey for overseas construction projects.

In addition, other cooperation is being extended to developing countries by more domestic organizations (Table 2-4-3).

Technological information is being made available to developing countries by a number of domestic organizations, including the Japan External Trade Organization, Research Development Corporation of Japan, Association of Japan Consultant Engineers, Patent Information Center and the Japan Chamber of Commerce and Industry.

Table 2-4-3. Major Private-Sector Technological Cooperation Organizations in Japan Which Are Offering Guidance and Training to Foreign Researchers

Name of organization	Cooperative activity
Asia hall	Offering lodging to Asian trainees, constructing welfare facilities for them, operating the facilities
OISCA Industrial Development Association	Dispatching engineers, accepting foreign trainees' training foreign engineers, holding international seminars/conferences
Overseas Engineering Training Association	Accepting foreign industrial technology
Overseas Fishery Cooperation Foundation	Financing overseas fishery projects, offering technological cooperation, dispatching specialists, accepting foreign trainees, nurturing specialists to be dispatched to foreign countries
Overseas Vocational Training Association	Collecting information and materials related to overseas vocational training, nurturing vocational trainers, recruiting local workers and providing their training
Overseas Communications/Broadcast Consulting Association	Inviting foreign communications engineers, accepting foreign researchers for training, facilitating study and training
Overseas Electric Power Research Council	Technical cooperation to overseas electric power development projects
Overseas Agriculture Development Association	Advice and guidance for overseas agriculture development cooperation, collecting and offering related information, conducting research and surveys for agriculture development
International Family Planning Cooperation Foundation	Dispatching family planning specialists and accepting foreign trainees, holding international conferences and research meetings
International Development Center	Nurturing experts for international development cooperation, comprehensive surveys and research concerning development research, dispatching Japanese people for study in foreign countries, inviting foreign development specialists

[continued]

[Continuation of Table 2-4-3]

Name of organization	Cooperative activity
International Technology Promotion Association	Publishing technological documents in languages of developing countries
International Nurse Exchange Association	Nurturing and training nurses for working in foreign countries, holding study and training sessions, organizing international exchange tours
International Construction Technology Association	Dispatching construction engineers and specialists, inviting foreign engineers
International Coastal Development Research Center	Holding international technology seminars on coastal development, dispatching specialists, conducting technology/development research to promote technological cooperation
Japan ILO Association	Efforts to popularize and enhance the ILO spirit, accepting foreign trainees
Japan International Medical Corps	Implementing program to establish Southeast Asia Medical Information Center, accepting foreign trainees, subsidizing training in foreign countries
Overseas Trade Development Association	Dispatching private sector specialists in the fields of production technology and corporate management
International Agriculture and Forestry Industry Cooperation Association	Collecting information about developing countries, investigating and researching them, training and securing specialists in international cooperation
Promotional Organization of Asian Agricultural Cooperatives	Collecting and updating information, conducting investigations and training for progress in Asian-region agricultural cooperative activities
International Traffic Safety Society	Collecting information about traffic control technology, conducting investigation and research, holding symposiums, inviting foreign researchers and trainees

Source: Foreign Ministry materials and other materials.

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